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Abstract	The Materials Engineering and Research Office, Soils and Aggregates Section, conducts an annual proficiency sample testing program for aggregate and soil materials to provide a means for participating laboratories of evaluating their performance. The Aggregate and Soil Proficiency Sample Testing Program includes tests related to Superpave consensus properties of aggregates. The laboratories are asked to perform a number of different tests on pairs of samples that have been prepared and randomly selected at the MTO Laboratory. The samples are delivered to the participating laboratories starting in June, and they report their results starting in early August. A preliminary report issued in mid-September allows the laboratories to examine their procedures or equipment and correct any problems that may have occurred. This year, two hundred and forty participants from the private and public sector participated in the Aggregate and Soil Proficiency Sample Testing Program. Sixty-one laboratories from the private sector and MTO Downsview laboratory reported results for all four of the Superpave consensus property tests. Results of the aggregate and soil tests from the 2015 program are found to be consistent with the results reported in the last three years, but, in a majority of the tests, the multi-laboratory variations show noticeable improvements over the ASTM, AASHTO or MTO precision estimates where available. Although there is improvement in the multi-laboratory variations, strong laboratory biases still remain in a few of the aggregate tests, three of the Superpave tests procedures and all of the soil tests. Sieve analysis results also show that the sample preparation method employed is very effective and capable of producing a uniform and nearly identical material at reasonable cost. We expect that the mandatory Laboratory Quality System implemented by CCIL and their lab inspection process will bring about improvements in multi-laboratory variations.
Key Words	Aggregate, consensus property, correlation, laboratory, proficiency testing, soil, Superpave
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Executive Summary

The Soils and Aggregates Section of the Materials Engineering and Research Office conducts an annual inter-laboratory proficiency sample testing program for aggregate and soil materials as a means for the Ministry of Transportation (MTO) to evaluate the competency of laboratories providing testing services in direct support of provincial highway construction and maintenance activities. The program also allows participants to evaluate their individual performance relative to other laboratories within the province. Test results are also used by the Canadian Council of Independent Laboratories for the independent certification of laboratories in Ontario.

Participation is mandatory for laboratories conducting quality assurance (QA) and referee testing for MTO contracts. Laboratories that perform quality control (QC) testing for contractors and materials suppliers participate voluntarily.

Each laboratory is asked to perform physical property and performance related tests, including Superpave aggregate tests[1], on randomly selected pairs of up to 6 different materials prepared by the Soils and Aggregates Section laboratories. Samples are delivered to the participating laboratories in early-June, who are required to prepare, test and report their results to MTO by the second week of August. An initial statistical analysis of the data is conducted by Soils and Aggregates staff and a preliminary report is issued in mid-September. This portion of the program is intended to give feedback to the participants while they are still operational during the current construction season and allows them to correct any problems that may exist with their procedures or equipment. A final report, including ratings for each laboratory, is issued after a full statistical analysis of the data has been completed.

Proficiency test samples were shipped to two hundred and forty-eight private and public sector laboratories who requested participation in 2015. Two hundred and forty of the participants submitted test results. Of these, one hundred and forty-seven were Quality Control (QC) laboratories operated by aggregate producers and road building contractors. The remaining laboratories were operated by engineering testing consultants and owners. Laboratory tests in were conducted in accordance with MTO, AASHTO and ASTM laboratory test standards[2].

Results of the aggregate and soil tests from the 2015 program are found to be consistent with the results from previous years and, in majority of the tests, the multi-laboratory variations show noticeable improvements over the precision estimates published by MTO, AASHTO or ASTM.

1 Only for the laboratory equipped to perform these tests
2 MTO (2016)

1. Introduction

This is the final report of the 2015 Aggregate and Soil Proficiency Sample Testing Program organized by the Ontario Ministry of Transportation for aggregate and soil test methods. This program is a means for participating laboratories to examine their testing processes and performance in relation to others. The information is also used by the ministry to establish criteria for selection of laboratories for Quality Assurance and Referee testing for MTO contracts[3]. Test results are also used by the Canadian Council of Independent Laboratories for the independent certification of laboratories in Ontario and allow the ministry to monitor the quality of those laboratories providing testing services to the government. Participation in this program became mandatory in 1998 for laboratories to qualify for ministry work.

The design of the proficiency sample testing program is based on procedures for determining the precision and variability of test methods. Interested readers should refer to ASTM C670[4], C802[5], E177[6], and E178[7] for further information on inter-laboratory testing programs.

Proficiency test samples were distributed to two hundred and forty-eight participants from the private and public sector laboratories in the summer of 2015. A total of two hundred and forty participants reported results, including seventy laboratories that reported results for one or more of the tests related to Superpave aggregate consensus properties. Participants in the testing program included both public (MTO Downsview laboratory, municipality laboratories) and private sector laboratories (contractors, aggregate producers, and engineering consultants). A preliminary report was issued to the participants in mid-September.

Laboratories conducted tests in accordance with MTO Laboratory Standards (MTO Laboratory Manual) and AASHTO/ASTM standards (where applicable). By request, each laboratory selects those test methods that they wish to participate in. A minimum number of tests are required by CCIL, depending on the type of laboratory certification required.

Coarse aggregate tests include material passing the 75 μm sieve by washing (LS-601), sieve analysis (LS-602), Los Angeles impact and abrasion loss (LS-603, ASTM C131), relative density and absorption (LS-604), sulphate soundness

3 Laboratories must also be inspected and recognized by the Canadian Council of Independent Laboratories (CCIL).
4 ASTM C670 Practice for Preparing Precision and Bias Statements for Test Methods of Construction Materials.
5 ASTM C802 Practice for Conducting an Inter-laboratory Test Program to Determine the Precision of Test Methods of Construction Materials.
6 ASTM E177 Practice for Use of Terms Precision and Bias in ASTM Test Methods.
7 ASTM E178 Practice for Dealing with Outlying Observations.

loss (LS-606, ASTM C88), percent crushed particles (LS-607), percent flat and elongated particles (LS-608), petrographic analysis (LS-609), insoluble residue (LS-613), unconfined freeze-thaw loss (LS-614), micro-Deval abrasion loss (LS-618) and percent asphalt coated particles (LS-621).

Fine aggregate tests include sieve analysis (LS-602), relative density and absorption (LS-605), petrographic analysis (LS-616), micro-Deval abrasion (LS-619), accelerated mortar bar expansion (LS-620) and one point proctor (LS-623).

Soil tests include particle size analysis (LS-702), Atterberg limits (LS-703/4, ASTM D4318) and relative density (LS-705).

Superpave consensus property aggregate tests include uncompacted void content of fine aggregate (LS-629, AASHTO T304), sand equivalent value of fine aggregate (ASTM D2419), percent fractured particles in coarse aggregate (ASTM D5821), and percent flat particles, elongated particles, or flat and elongated particles in coarse aggregate (ASTM D4791).

Reports to individual laboratories contain ratings for each test method that are based on the standardized deviate for that test, i.e., ratings range from ±5 for data within 1.0 standard deviation of the mean to a rating of 0 for data 3.0 or more standard deviations from the mean. Ratings of each test method are also used to calculate an overall laboratory rating. This rating system has acted as an incentive for laboratories to improve their performance.

Particularly, sieve analysis of coarse aggregate, relative density and absorption of both coarse and fine, percent crushed particles of coarse aggregate, percent flat and elongated particles of coarse aggregate, amount of asphalt coated particles, moisture density relationship (one-point Proctor), Atterberg limits and specific gravity of soils show improvements over the precision estimates published by MTO, AASHTO or ASTM. Although the precision of most of the aggregate test methods compares favourably in relation to the results of previous studies and the precision estimates where available, strong laboratory biases still remain in the following test methods: relative density and absorption of fine aggregate (LS-605), magnesium sulphate soundness of coarse aggregate (LS-606), insoluble residue of carbonate aggregates (LS-613), Micro-Deval abrasion of fine aggregates (LS-619), and accelerated mortar bar (LS-620). The variations in soil test results show improvement and are lower than the values reported in the previous three years of study, but the scatter plots of all three soil tests show a strong laboratory bias.

The results of Superpave consensus property tests from the 2015 program also compare favourably with the past performance of the laboratories. The multi-laboratory variations of uncompacted void content (LS-629) and percent flat and elongated particles of coarse aggregate (D4791) tests show noticeable improvements over the values reported in the past two years. The multi-laboratory variations of percent fractured particles of coarse aggregate (D5821) tests show noticeable improvements over the precision estimates published by

ASTM. Although, there is noticeable improvement in the performance of the laboratories, the scatter diagrams for LS-629, ASTM D2419 and D5821 show strong laboratory biases.

The computer program that was developed by MTO to handle the computation and presentation of test data has two statistical methods to detect outlying observations or outliers in a set of data, namely the Critical Value Method recommended in Section 4 of ASTM E178 and the Iterative (Jack-knife) Technique recommended by Manchester[8] (1979) . For details of the program, refer to the User's Manual (MERO-013) by Vasavithasan and Rutter, 2004. A number of statistical methods are available to test the hypothesis that the suspect observations are not outliers. MTO often follows the Critical Value Method to remove outliers. However, the Jack-knife method is used where the strict application of the Critical Value method tends to include extraneous results that may not stand the best chance of representing the testing performed in conformance with each of the test methods. The Critical Value method and iterative techniques are based on two different statistical approaches. As a result, the confidence intervals yielded by these two methods differ widely depending on the number of observations (number of laboratories participating in a particular test method) and the distribution of data. In the case of Iterative Technique, test results that fall beyond 2.8 times the standard deviation from the mean may be identified as outliers depending on the number of observations and distribution of data.

The critical value used in this study is that value of the sample criterion, which would be exceeded by chance with some specified probability (significance level) on the assumption that all observations in the sample come from the same normally distributed population. The critical values provided in ASTM E178, Table 1 are limited to 147 observations, even though over 225 laboratories participate in our annual testing program. The critical values used for this study were calculated at a five percent significance level (Grubbs' test) based on Grubbs' (1969 and 1972) recommendations for identifying outliers.

8 The Development of an Interlaboratory Testing Program for Construction Aggregates, by L. Manchester, Ministry of Transportation, Ontario, Engineering Materials Office Report EM-33, Downsview, December, 1979.

2. Test Results

2.1 TABLE OF TEST RESULTS

Each participant receives an individual summary of results for their laboratory. An example of a typical report is shown in Tables 1, 2, 3, and 4. Each Table of Results identifies the laboratory by number and compares the laboratory's data with the means obtained after statistical analysis of the data received from all laboratories. The identity of the laboratories is kept confidential.

Column 1 gives the test method as designated in the MTO Laboratory Testing Manual.

Columns 2 and 3 show the test data submitted by the laboratory for a pair of samples.

Columns 4 and 5 show the mean (average) test value for each sample after removal of outliers and/or invalid test results from the data set for all laboratories performing the test.

Columns 6 and 7 list the standardized deviate for each test result. The standardized deviate is used to show how the individual test results compare to the mean. It is obtained by subtracting the mean of all data ($\overline{X}$) from the actual test result reported by the laboratory (X_i) and dividing by the standard deviation (s). That is:

$$\text{Standardized Deviate} = \frac{\left(X_i - \overline{X}\right)}{s}$$

If the test result is less than the mean, the standardized deviate is negative and, if the test result is greater than the mean, the standardized deviate is positive. In brief, the standardized deviate tells us how many standard deviations the test result is away from the mean.

Columns 8 and 9 list the test method ratings, which are similar to the standardized deviate, but are in a simple numeric form. Ratings are determined as follows:

Rating 5 - data within 1.0 standard deviation of the mean.
Rating 4 - data within 1.5 standard deviations of the mean.
Rating 3 - data within 2.0 standard deviations of the mean.
Rating 2 - data within 2.5 standard deviations of the mean.
Rating 1 - data within 3.0 standard deviations of the mean.
Rating 0 - data 3.0 or more standard deviations from the mean or data considered to be outlying by other methods.

A negative sign simply indicates a result that is smaller than the mean. If one of the paired test results for a given test is excluded based on the outlier criteria, the

other test result is still subjected to the statistical analysis and is only excluded if it also fails to meet the criteria.

An outlying observation is one that appears to deviate markedly from the sample population. It may be merely an extreme manifestation of the random variability inherent in the data, or may be the result of gross deviation from the prescribed experimental procedure, calculation errors, or errors in reporting data. The outlier criteria employed for exclusion of test results from the analysis will depend on the distribution of data and the number of participants in a test. The iterative technique is one of the methods employed in this study for the selection of outliers, and is used where the strict application of critical value method tends to include the data that does not belong to the population. In the critical value method, the standardized deviate of a lab result is compared with the critical value corresponding to the number of participants in that particular test, for rejecting an outlier. The critical value is greater than 3 when the number of participants in a particular test method is 30 or more. For this reason, results with more than 3 standardized deviates may not have been identified as an outlier unless it is higher than the critical value, but a zero rating is nevertheless assigned for the test result in question. For example, if the computed standardized deviate for a lab result is 3.236 and the critical value corresponding to the number of participants in that particular test is 3.427, the lab will not be identified as an outlier but a zero rating will be assigned.

Significance need not necessarily be attached to a single low rating. However, a continuing tendency to get low ratings on several pairs of samples or on a series of tests from one procedure, e.g., sieve analysis, should lead a laboratory to re-examine its equipment and test procedure. A laboratory that reports data for a specific test consistently lower or higher than the mean over a number of test periods also needs to re-examine their test procedure, because this is evidence of a systematic bias in how the laboratory conducts the procedure. Any computer program that is used by a laboratory to calculate test results should be verified as part of this examination.

2.2 SCATTER DIAGRAMS

Youden scatter diagrams are supplied with this report (see Appendices D1 and D2). A laboratory can locate itself on the diagrams by plotting its test value for the first sample (1.15) on the horizontal axis, against its test value for the second sample (2.15) on the vertical axis. The horizontal and vertical axes are of equal length and are scaled to give the most informative display of the plotted points. In some cases, the outlying results plot outside the boundaries of the diagram. If the results from two or more laboratories happen to coincide, a single point is plotted.

Below each scatter diagram, the test number and title are given, followed by a table of statistical calculations for both samples. Here the mean, median, and standard deviation for each sample are given. The number of laboratories reporting valid data and the laboratories eliminated by statistical analysis are also listed.

The vertical and horizontal crosshairs on the plots represent the mean values for all the valid results on the first sample (1.15) and the second sample (2.15), respectively. These lines divide the diagram into four quadrants, numbered 1 through 4, beginning in the upper right-hand quadrant and continuing clockwise. In an ideal situation where only random errors occur, the points are expected to be equally numerous in all quadrants and will form a circular distribution. This follows because plus and minus errors should be equally likely. Often, however, the points tend to concentrate in quadrants 1 and 3 on the diagram. This occurs because laboratories tend to get high or low results on both samples. This gives evidence of individual laboratory biases. As the tendency to laboratory bias increases, the departure from a circular distribution of points towards a linear (elliptical) distribution from quadrant 1 to 3 occurs. Such a distribution of points indicates systematic variation. Figure 1 gives examples of scatter diagrams.

Table 1. Summary of Results for Laboratory 47

TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: October 30, 2015					
COARSE AGGREGATE REFERENCE SAMPLES 1.15 & 2.15								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	1.15	2.15	1	2	1	2	1	2
LS-601 Wash Pass 75 μm (Coarse Agg.)	2.100	**2.600**	1.838	**1.844**	1.043	***3.068**	4	**0**
LS-602 – Coarse Aggregate								
Percent Passing 19.0 mm	98.400	97.100	98.143	97.921	0.555	-1.477	5	-4
Percent Passing 16.0 mm	91.200	89.600	90.898	90.047	0.331	-0.375	5	-5
Percent Passing 13.2 mm	83.600	80.800	82.380	80.930	1.035	-0.092	4	-5
Percent Passing 9.5 mm	68.900	67.900	68.753	66.755	0.143	0.692	5	5
Percent Passing 4.75 mm	50.460	51.500	52.184	50.386	-1.627	0.753	-3	5
LS-603 Los Angeles Abrasion, %	25.300	24.800	25.040	25.050	0.188	-0.324	5	-5
LS-606 – Coarse Aggregate $MgSO_4$ Soundness Loss, %	1.700	1.400	2.250	2.443	-0.722	-0.980	-5	-5
LS-606 – Fine Aggregate $MgSO_4$ Soundness Loss, %								
LS-607 Percent Crushed Particles	64.600	65.200	64.611	65.186	-0.003	0.003	-5	5
LS-608 % Flat & Elongated Particles	2.900	2.300	3.469	3.320	-0.470	-0.815	-5	-5
LS-609 Petrographic Number (Concrete)	129.00	126.40	115.35	114.68	1.835	1.877	-	-
LS-613 Total % of Insoluble Residue Insoluble Residue Retained 75μm								
LS-614 Freeze-Thaw Loss, %	2.100	1.600	1.742	1.720	0.526	-0.180	5	-5

Blank spaces represent not tested.
Bold and Underline * - Calculation considered outlier
∩ - Outliers by Manual Deletion

Table 2. Summary of Results for Laboratory 47

TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: October 30, 2015					
FINE AGGREGATE REFERENCE SAMPLES 1.15 & 2.15								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	1.15	2.15	1	2	1	2	1	2
LS-618 Micro-Deval Abrasion Loss (CA)	8.400	8.500	8.818	8.776	-0.808	-0.437	-5	-5
LS-620 Accelerated Mortar Bar (14 Days)	0.113	0.123	0.173	0.179	-2.009	-1.530	-2	-3
LS-623 Maximum Wet Density (g/cm^3) Maximum Dry Density (g/cm^3) Optimum Moisture, %	 2.420 2.260 7.100	 2.438 2.280 6.950	 2.431 2.273 7.002	 2.435 2.278 6.944	 -0.434 -0.464 0.358	 0.102 0.062 0.020	 -5 -5 5	 5 5 5
LS-604 – Coarse Aggregate Relative Density (O.D.) Absorption	 2.684 1.190	 2.689 1.150	 2.688 1.188	 2.688 1.186	 -0.554 0.029	 0.162 -0.535	 -5 5	 5 -5
LS-621 Asphalt Coated Particles, %	36.600	36.000	36.559	32.251	0.015	1.026	5	4

Blank spaces represent not tested.
Bold and Underline * - Calculation considered outlier
∩ - Outliers by Manual Deletion

Table 3. Summary of Results for Laboratory 47

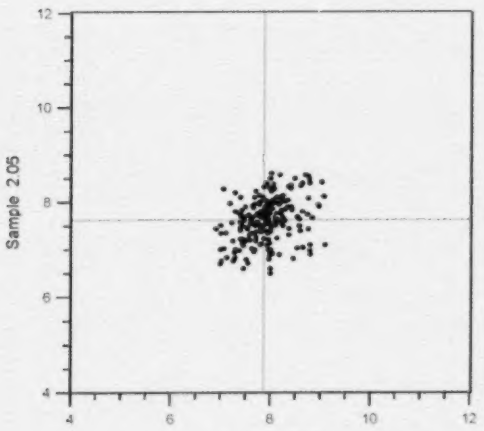
TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: October 30, 2015					
FINE AGGREGATE REFERENCE SAMPLES 3.15 & 4.15								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	3.15	4.15	3	4	3	4	3	4
LS-605 – Fine Aggregate								
Relative Density (O.D.)	2.697	2.717	2.711	2.712	-1.189	0.453	-4	5
Absorption	1.450	1.110	1.129	1.105	2.302	0.039	2	5
LS-619 – Fine Aggregate								
Micro-Deval Abrasion	13.700	14.300	15.909	15.705	-1.672	-0.889	-3	-5
LS-602 – Fine Aggregate								
Percent Passing 2.36 mm	40.600	43.300	42.382	40.992	-1.297	1.260	-4	4
Percent Passing 1.18 mm	32.600	35.600	34.035	33.105	-0.897	1.292	-5	4
Percent Passing 600 μm	24.700	27.200	25.616	25.127	-0.659	1.201	-5	4
Percent Passing 300 μm	16.500	18.100	16.793	16.680	-0.326	1.159	-5	4
Percent Passing 150 μm	10.800	11.700	11.127	11.074	-0.506	0.753	-5	5
Percent Passing 75 μm	6.720	7.200	6.739	6.780	-0.043	0.823	-5	5

Blank spaces represent not tested.
Bold and Underline * - Calculation considered outlier
∩ - Outliers by Manual Deletion

Table 4. Summary of Results for Laboratory 47

TEST RESULTS FOR LABORATORY NUMBER 47			DATE PREPARED: October 30, 2015					
SOILS REFERENCE SAMPLES 5.15 & 6.15								
TEST METHOD	LABORATORY DATA		MEAN OF LABORATORIES		STANDARDIZED DEVIATE		LAB RATING	
	5.15	6.15	5	6	5	6	5	6
LS-702 – Sieve Analysis of Soil								
Percent Passing 2.00 mm	99.900	99.900	99.886	99.871	0.063	0.118	-	-
Percent Passing 425 µm	97.700	97.700	97.376	97.574	0.890	0.386	5	5
Percent Passing 75 µm	91.800	92.900	91.786	92.011	0.030	1.715	5	3
Percent Passing 20 µm	82.800	81.700	82.269	82.708	0.160	-0.307	5	-5
Percent Passing 5 µm	71.000	72.500	72.933	73.246	-0.652	-0.237	-5	-5
Percent Passing 2 µm	64.100	63.200	62.614	63.208	0.451	-0.003	5	-5
LS-703								
Liquid Limit, %	48.000	49.600	47.371	47.607	0.328	0.849	5	5
LS-704								
Plastic Limit, %	22.900	22.500	21.153	21.313	1.174	0.788	4	5
Plasticity Index, %	25.100	27.100	26.549	26.370	-0.650	0.297	-5	5
LS-705								
Specific Gravity of Soil	2.724	2.722	2.747	2.751	-0.900	-1.100	-5	-4
AGGREGATE CONSENSUS PROPERTIES								
Uncompacted Void Content	43.600	43.400	43.557	43.681	0.082	-0.579	5	-5
Sand Equivalent Value	65.500	61.500	53.719	53.289	1.362	0.946	4	5
Percent Fractured Particles	63.600	66.200	66.653	66.944	-0.646	-0.173	-5	-5
% Flat & Elongated Particles	0.300	0.200	0.774	0.765	-1.138	-1.303	-4	-4

Blank spaces represent not tested.
Bold and Underline * - Calculation considered outlier
∩ - Outliers by Manual Deletion

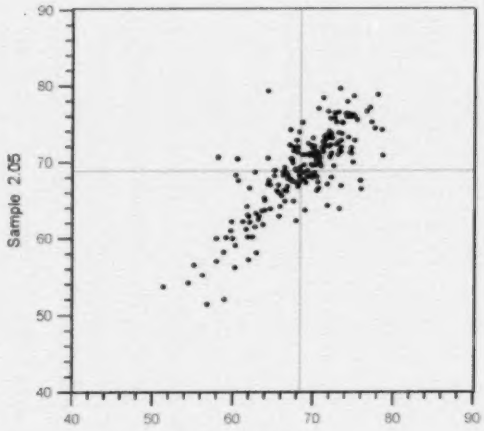


Test 25: Percent Passing the 75 um Sieve

	Mat 1	Mat 2
Mean	7.930	7.630
Median	7.800	7.500
Std Dev	0.460	0.470
n = 203		

Labs Eliminated: 447, 497, 452, 518

Scatter diagram for a test showing random variation with little laboratory bias

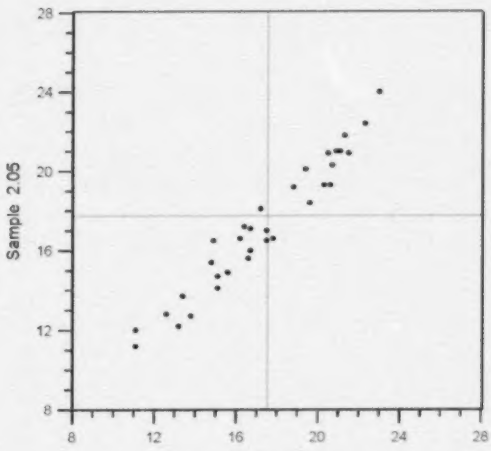


Test 12: Percent Crushed Particles

	Mat 1	Mat 2
Mean	68.491	68.905
Median	68.300	64.500
Std Dev	5.054	5.402
n = 201		

Labs Eliminated: 345, 350, 436, 480

Scatter diagram for a test showing a combination of random variation and laboratory bias for some laboratories

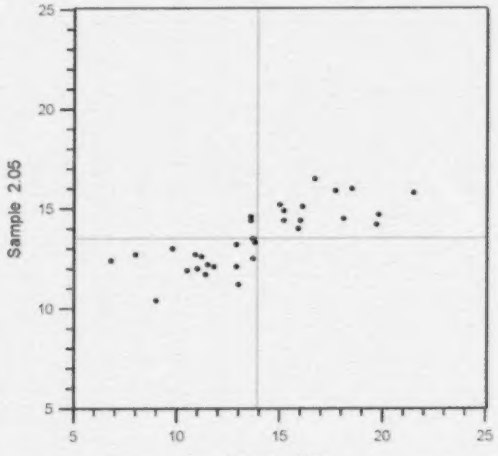


Test 29: MgSO4 Soundness (Fine Aggregate), % Loss

	Mat 1	Mat 2
Mean	17.370	17.258
Median	15.800	15.600
Std Dev	3.276	3.325
n = 32		

Lab Eliminated: None

Scatter diagram for a test showing pronounced between laboratory bias and equal variation for each material



Test 11: MgSO4 Soundness (Coarse Aggregate), % Loss

	Mat 1	Mat 2
Mean	13.890	13.570
Median	12.900	13.600
Std Dev	3.533	1.541
n = 31		

Lab Eliminated: None

Scatter diagram for a test with pronounced between laboratory bias but unequal variation for each material

Figure 1. Examples of Youden Scatter Diagrams

2.3 OUTLIERS

In dealing with suspected outlying observations or 'outliers', the purpose is to remove those observations that do not belong to the sample population and provide the statistical criteria for doing so. For most cases, ASTM E178 states: "the doubtful observation is included in the calculation of the numerical criterion (or statistic), which is then compared with a critical value based on the theory of random sampling to determine whether the doubtful observation is to be retained or rejected". The critical value is that value of the sample criterion that would be exceeded by chance with some specified (small) probability on the assumption that all observations did indeed constitute a random sample from a common system of causes, a single parent population, distribution, or universe.

This study follows the criteria recommended for single samples in Section 4 of ASTM E178 for rejecting the doubtful observations at the ninety-five percent confidence level. The Critical Value method is based on the assumption of normality, and the critical values are calculated using Student's T distribution. The assumption in this method is that all of the observations come from the same normal population. The doubtful observation is included in the calculation of mean and standard deviation of the population. Then the critical value, T_n, for that observation, n, in question is calculated and compared with the critical value based on the theory of random sampling. The doubtful observation is rejected if T_n is higher than the critical value for the five percent significance level. The outlier is removed from the data set and the iterations are continued until no outliers are detected. A revised mean and standard deviation are calculated after deleting the outlier. Ratings for the laboratories are determined based on the revised mean, standard deviation, and standardized deviate.

In some cases, the strict application of the Critical Value method tends to include laboratories in the population that report extraneous results. These results may not represent testing performed in conformance with the test method. In those cases, the application of the Iterative Technique (Manchester) is used. The Constant C in the Iterative Technique is computed using Fisher's F distribution, and depends on the number of participating laboratories in a particular test. In this technique, an outlying observation is rejected based on a statistical criterion, but the confidence interval may vary depending on the number of participants and the distribution of sample population.

In the Iterative Technique, after screening test results for any errors, the doubtful test result is included in the calculation of mean and standard deviation of the data set. The absolute residual values (actual test result minus the mean) are then computed and the test result farthest from the mean by a unit of Cs (standard deviation, s, multiplied by a constant C) is identified as an outlier. One outlier at a time is identified and rejected in a manner similar to that of Critical Value method.

Four of the test methods included in this proficiency sample testing program requires reporting of control sample results to demonstrate that the testing

process of the laboratory is in control. The laboratories that report control sample results outside the range of values established for the material are identified during the screening of test results for any errors or deviations. These laboratories are manually removed from the data set during the analysis and considered as outliers.

3. Discussion

The following discussion contains general and test-specific comments for the 2015 test period. Where ASTM, AASHTO or MTO precision statements are published for a given test, an attempt has been made to compare these with the statistics for this period.

A discussion of statistical techniques is presented in the Glossary of Terms, found in Appendix A.

3.1 MATERIAL SOURCES

Materials used in this test period were as follows:

- Granular A (OPSS 1010) from Harold Sutherland Construction's Redford Pit, Durham, Grey County, Owen Sound (MTO MAIDB No. W01-154). Coarse and fine aggregate tests, including Sieve Analysis, Magnesium Sulphate Soundness Loss (coarse), Percent Crushed Particles (coarse), Moisture Density Relationship, Relative Density and Absorption (fine), Micro-Deval Abrasion Loss (fine), Uncompacted Void Content, Sand Equivalent Value, and Percent Fractured Particles.
- Coarse Aggregate from Harold Sutherland Construction's Redford Pit, Durham, Grey County, Owen Sound (MTO MAIDB No. W01-154).Coarse aggregate tests, including Wash Pass 75 □m sieve, Percent Flat and Elongated Particles, Relative Density and Absorption, Los Angeles Abrasion Loss, Micro-Deval Abrasion Loss, Freeze-Thaw Loss, and Percent Flat, Elongated, or Flat and Elongated Particles.
- Natural sand from a source located in Stouffville Area. Fine Aggregate Petrographic Examination and Insoluble Residue of Carbonate Aggregates.
- Natural sand from a source located in Stouffville Area; control aggregate from the Spratt Quarry located near Ottawa. Accelerated Mortar Bar Test.
- Soil tests – Port Colbourne Quarry (MTO MAIDB No. W03-002).

3.2 SAMPLE PREPARATION

The material processed for the coarse and fine aggregate tests conforms approximately to the gradation requirements of OPSS Granular A. Bulk samples were prepared by MTO using a large spinning riffler, developed and built by staff at the MTO Downsview Laboratory (refer to Figures 2 and 3 of Report MI-179, February 2000). The use of a spinning riffler ensures that, as far as possible, each sample is identical to every other sample. It has been found that this is the best technique for minimizing sample bias.

A bobcat loader was used to move aggregates from the stockpile to a hopper/bin which fed material onto a conveyor belt to fill 33 sample bags (fitted with funnels)

on a spinning turntable. About 25 revolutions of the turntable were required to fill each bag with 27 ± 2 kg of material (underweight or overweight bags are rejected). In total, seven hundred ~27kg samples of Granular A were prepared for the coarse and fine aggregate tests. The samples were individually randomized in 350 pairs for distribution to participating laboratories. Each participant was responsible for the preparation of their own fine aggregate samples (3.15 and 4.15) from the pair of Granular A samples supplied.

In addition to the Granular A samples, a coarse aggregate with approximately 95% material retained on 4.75 mm sieve was also supplied. The turntable required about 26 revolutions for this material to fill each sample bag to approximately 28 ± 2 kg. In total, seven hundred ~28kg samples were prepared and randomized in pairs for distribution to participating laboratories.

Soil material was air-dried and mechanically broken down and passed through a 4.75mm sieve to remove oversized particles. The passed 4.75mm material was then processed to pass through a 2.0 mm sieve using a Fritsch Soil Mill Pulveriser and placed in 20 kg buckets. Individual scoops were collected from each bucket and placed in a separate container. The material from the container was then transferred to the hopper of a small spinning riffle splitter capable of filling 24 identical 2 kg containers per run. This method was used to create uniform 500 g proficiency test samples that were then randomized in pairs for distribution to participating laboratories.

3.3 NOTES ON INDIVIDUAL TESTS

For each test, comments have been made pertaining to the variation illustrated by the associated scatter diagrams shown in Appendices D1 and D2. The technique used to test for outliers is stated and where possible, reasons for the outlying observations are offered. It is important to keep in mind that there are many variables influencing laboratory testing.

A summary of the statistical data is presented in the Multi-Laboratory Precision Tables found in Appendix C. Along with the comparison made to ASTM, AASHTO or MTO precision statements, comparison of the variation between previous test periods is made for each of the tests. Because the materials usually differ from year to year, it is emphasized that the comparison between years should be used only as a guide. It is important to note that the yearly use of different materials will have some effect on the variation exhibited in some tests, while it will have relatively little effect on others. For example, the magnesium sulphate soundness test normally exhibits increased variation as higher mean loss is reported. A coarse aggregate sample having an average mean loss of twenty percent would likely show more variation than a coarse aggregate sample having an average mean loss of ten percent. On the other hand, a sieve analysis could be performed on those same two aggregates, with the percent passing each sieve and the variation being remarkably similar for the two samples.

3.4 PROFICIENCY SAMPLE TESTS

3.4.1 LS-601 - Wash Pass 75 µm (Coarse Aggregate) – Test No. 1

Two hundred and twenty-six laboratories reported results for this test in 2015. Nineteen outliers were identified and rejected using the iterative technique. The standard deviations of 0.251 and 0.247 obtained in 2015 are higher than the values that were reported in the 2014 study and comparable to the values that were reported in 2012 and 2013 studies. The standard deviations obtained in 2015 are slightly higher than the multi-laboratory variation of 0.20 published in the MTO Test Method LS-601 for aggregates with less than 2.5% material passing the 75 µm sieve and that of the value of 0.22 published by ASTM C 117 for aggregates with 1.5% of material finer than the 75 µm sieve. The mean value of the aggregate used in 2015 consisted of approximately 1.8% material finer than 75 µm, which is in line with the values for which the ASTM and MTO precision statements were established. Further, the coefficient of variation of 13.5% obtained in 2015 is lower than the values of 15.8% reported in 2014 and the value of 21.7% reported in 2013. The scatter diagram provided in the Appendix D1 shows a combination of random variation and laboratory bias for some laboratories. The laboratories that are identified as outliers should examine their test procedure more closely, especially the achievement of constant dry mass at the beginning and end of the test.

3.4.2 LS-602 - Sieve Analysis (Coarse Aggregate) – Test Nos. 2 to 6

These tests represent the coarse aggregate portion of the Granular A sample gradation. Tests 20-25 carried out on the material passing 4.75 mm sieve as prepared by the participants (samples 3.15 and 4.15) represent the remainder of the gradation. The data is presented in percent passing format and is compared to precision statements developed in the same format by Vogler and Spellenberg[9].

The Granular A samples 1.15A and 2.15A supplied for the sieve analysis test consisted of approximately 49% of the material retained on 4.75 mm sieve, and conform to the grading of Granular A materials used in the past MTO Aggregate and Soil Proficiency Sample Testing Programs. The gradings reported for Test Nos. 2-6 represent the combined gradings of coarse and fine aggregates. The proficiency test samples were prepared with the large spinning riffler described in Section 3.2.

The standard deviations obtained in 2015 for all of the sieves, with the exception of 19.0 mm sieve, are found to be significantly lower than the expected variations given in the ASTM C 136 precision statements. In the case of 19.0 mm sieve, the standard deviations of 0.46 and 0.56 obtained are higher than the precision estimate of 0.35 published by ASTM.

9 Vogler, R.H., Department of Transportation, Michigan, AASHTO Technical Section 1c; T27 and Spellenberg, P.A., AASHTO Materials Reference Laboratory; Unpublished Paper.

Two hundred and twenty-six laboratories reported results for the sieve analysis test in 2015. Outliers were eliminated using the iterative technique. Successive scatter diagrams show a fairly uniform distribution of points about the mean (i.e. a random variation with little laboratory bias). The number of outliers identified varies from sieve to sieve, and ranges from four for the 19.0 mm sieve to a maximum of sixteen for 4.75 mm sieves.

Possible reasons for outlying observations include factors that impact the measurement process such as sieve condition (state of repair and cleanliness), efficiency of the sieving process and apparatus, initial sample mass, and mass on a given sieve. If your laboratory has performed poorly in this test period, you should inspect your sieves (use CAN/CGSB-8.1-88 or ASTM E11 as guides) and your sieve shaker(s) thoroughly, and, once satisfied that they are in order, perform a sieving efficiency test as described in LS-602 to pinpoint any problems.

3.4.3 LS-603 - Los Angeles Abrasion Loss (Coarse Aggregate) – Test No. 8

Only ten laboratories reported results for this test in 2015. No outlier was detected by the use of critical value method or iterative technique. Considering the number of observations (10) used, the analysis may not yield any meaningful or representative statistical data. The lower left and upper right quadrants together account for six of the ten points, showing a combination of random variation and laboratory bias for some laboratories. This test shows unequal variation for each material. However, the standard deviations obtained in 2015 are comparable to that of the values reported in the past three years.

ASTM precision statements for 19.0 mm maximum size coarse aggregate, with percent loss in the range of 10% to 45%, give a multi-laboratory coefficient of variation of 4.5%. Therefore, the results from two different laboratories should not differ by more than 12.7%. The mean loss of 25.1% in this test is within the range of values for which ASTM C 131 data was established. This year's coefficient of variation (average 4.3%) is consistent with the value, 4.5%, given in the ASTM precision statements.

3.4.4 LS-604 - Relative Density of Coarse Aggregate – Test No. 9 and Absorption of Coarse Aggregate – Test No. 10

MTO Test Method LS-604 follows the procedures described in ASTM C 127-12 for the determination of relative density (Test No. 9) and absorption property (Test No. 10) of coarse aggregates. ASTM C 127 provides precision statements only for relative density. It does not provide precision estimates for the absorption property. In the case of LS-604, it provides precision estimates for both relative density and absorption of coarse aggregates with absorption properties less than 2.0%. The precision statements published in LS-604 were established using the data collected for a period of fourteen years, through the MTO Proficiency Sample Testing Program.

Ninety-nine laboratories reported results for these tests in 2015. Six laboratories for relative density and seven laboratories for absorption were identified as outliers using the iterative technique. The standard deviations of 0.007 and 0.006 obtained for bulk relative density in 2015 are consistent with the values reported in 2013 and 2014 as well as the precision estimate of 0.006 published in the LS-604. Further, the standard deviations obtained in 2015 are one-half of the value of 0.013 published in ASTM C 127. In the case of absorption test, the standard deviations of 0.066 and 0.067 obtained this year are lower than the precision estimate of 0.09 provided in the LS-604. In addition, the coefficient of variation of 5.6% obtained in 2015 is considerably lower than the values 6.1% to 10.6% reported in the past three years. The scatter diagram for Test No. 9 shows a combination of random variation and laboratory bias for some laboratories. The scatter diagram for Test No. 10 shows a strong between laboratory bias.

3.4.5 LS-606 - Magnesium Sulphate Soundness (CA) – Test No. 11

Forty-two laboratories reported results for this test in 2015. Two outliers were identified by the use of iterative technique. The scatter diagram shows a pronounced between laboratory bias. Majority of the points (85%) are accounted in the lower left and upper right quadrants. This test has historically shown high coefficients of variation due to the difficulty of maintaining solution of the correct density and insufficient drying by some laboratories. The average mean loss of 2.3% in this test is significantly lower than the range of values (9% to 20%) for which the ASTM C 88 precision estimate was established. The coefficient of variation of 39% obtained in 2015 is significantly higher than the value of 25% reported in 2014 and the value published in the ASTM precision statements. ASTM reports a multi-laboratory coefficient of variation of 25% for coarse aggregate with percent loss in the range of 9% to 20%.

3.4.6 LS-607 - Percent Crushed Particles – Test No. 12 and Percent Cemented Particles – Test No. 7

The coarse aggregate samples supplied did not contain adequate amount of material retained on the 19.0 mm sieve. For this reason, participants were advised to perform the test only on coarse aggregate passing the 19.0 mm sieve and to calculate the weighted average by assigning the same percent crushed particles value as the next smaller fraction (i.e., 19.0 mm - 13.2 mm) for 26.5 mm to 19.0 mm that need not be tested.

This year, two hundred and twenty-six laboratories submitted results for this test. Participants in this test were asked to compute the percent of each fraction using the gradation test results of the coarse aggregate portion, based on the total mass of material retained on 4.75 mm sieve. And all five fractions of the Granular A sample shall be used in calculation of the weighted average of percent flat and elongated particles, as specified in the instructions. Sixteen of the participants did not follow the instructions and calculated the percent fractions simply based on

the minimum mass requirements for each fraction in Table 1 of the LS method. Six of the participants included the material passing 4.75 mm sieve in the calculation of the total mass of the coarse aggregate portion. Twelve of the participants did not use all five fractions in the calculation. In addition, one of the participants did not follow the instructions and performed the test on the coarse aggregate samples. And one of the participants did not assign the percent crushed particles value for 26.5 mm to 19.0 mm as instructed. These thirty-six laboratories were removed from the analyses manually and were identified as outliers. In addition, fourteen laboratories were selected as outliers by employing the iterative technique. The standard deviations of 4.2 and 4.1 obtained in 2015 are lower than the precision estimate of 4.7 published in the MTO LS-607 but higher than the values ranging from 3.2 to 3.8 reported in the past two years. The standard deviations obtained in 2015 are also significantly lower than the value of 6.0 obtained during the 1989 MTO workshop. The average mean value of 64.9% in this test is within the range of values (55% to 85%) for which the MTO precision statements were established. The scatter diagram shows a combination of random variation and operator bias for some laboratories. ASTM has a very similar test method (D 5821) but has not conducted inter-laboratory studies to determine precision and currently publishes precision data (standard deviation of 5.2 for a mean percent crushed particles value of 76.0%) obtained from MTO study.

3.4.7 LS-608 - Percent Flat and Elongated Particles – Test No. 13

The determination of a flat and/or elongated particle is dependent on operator skill and judgement in using the measurement tool. The ASTM and CSA procedures use a proportional calliper device to measure the *greatest* length or width to thickness ratio. The MTO procedure previously measured the ratio of *mean* length or width to the *mean* thickness (MTO Laboratory Manual Revision 15 and earlier). The MTO procedure (Revision 16 and up) has been modified to agree with the ASTM definition. All participants should be using the latest MTO version of the test method. Flat and elongated particles are defined in the MTO Test Method LS-608 as those pieces whose greatest dimension in the longitudinal axis, compared to the least dimension in a plane perpendicular to the longitudinal axis, exceeds a ratio of 4:1. This test method is similar to that of ASTM D 4791 and uses the same definition, with the exception of ratio, for the flat and elongated particles. In ASTM, the flat and elongated particles are defined as the pieces that exceed a ratio of 3:1 or 5:1. In LS-608, the test sample is separated into number of fractions and the weighted average of percent flat and elongated particles is calculated using the result of every fraction tested.

The coarse aggregate samples supplied did not contain adequate amount of material retained on the 19.0 mm sieve. For this reason, participants were advised to perform the test only on coarse aggregate passing the 19.0 mm sieve and to calculate the weighted average by assigning the same percent flat and elongated particles value as the next smaller fraction (i.e., 19.0 mm - 13.2 mm) for 26.5 mm to 19.0 mm that need not be tested.

This year, two hundred and twenty-six laboratories submitted results for this test. Participants in this test were asked to compute the percent of each fraction using the gradation test results of the coarse aggregate portion, based on the total mass of material retained on 4.75 mm sieve. And all five fractions shall be used in calculation of the weighted average of percent flat and elongated particles, as specified in the instructions. Sixteen of the participants did not follow the instructions and calculated the percent fractions simply based on the minimum mass requirements for each fraction in Table 1 of the LS method. Fourteen of the participants included the material passing 4.75 mm sieve in the calculation of the total mass of the coarse aggregate portion. Nine of the participants did not use all five fractions in the calculation. One of the participants used incorrect data from the gradation test resulting in miscalculation of the weighted average. These forty laboratories were removed from the analyses manually and were identified as outliers. In addition, six laboratories were selected as outliers by employing the iterative technique. LS-608 provides precision estimate for coarse aggregate passing 19.0 mm and retained on 4.75 mm with percent flat and elongated particles ranging from 2.0% to 9.5%. The standard deviations of 1.21 and 1.25 obtained in 2015 are significantly lower than that of the values (1.7 to 2.5) reported in the past 3 years. The multi-laboratory variations obtained in 2015 are also significantly lower than the precision estimate of 2.3 published in LS-608. The average mean value of 3.4% in this test is within the range of values (2% to 9.5%) for which the MTO precision statements were established.

ASTM D 4791 is similar to LS-608 for comparison of multi-laboratory precisions obtained. In ASTM, the precision estimates are provided for individual fractions ranging from 19.0 mm to 4.75 mm (19 mm to 12.5 mm, 12.5 mm to 9.5 mm, and 9.5 mm to 4.75 mm), and the estimates are based on the coefficient of variation. A direct comparison of the precision estimates from ASTM is not appropriate with that of the estimates provided in LS-608. The precision estimates published in LS-608 are on the basis of standard deviation, and was estimated from the weighted averages calculated using the results of four fractions ranging from 19.0 mm to 4.75 mm.

The scatter diagram provided in the Appendix D1 shows a combination of random variation and laboratory operator bias for some laboratories. In general, laboratories that reported values in excess of 5.8% or less than 0.9% should critically examine their equipment and procedure.

3.4.8 LS-609 - Petrographic Analysis (Coarse Aggregate) – Test No. 14

The coarse aggregate examined in 2015 Proficiency Sample Test Program was derived from a pit source in the Nakina area, located east of Lake Nipigon. Surficial deposits in this area contain mainly siliceous rock types derived from the underlying Precambrian Shield as well as carbonates and cherts derived from the Hudson Bay Lowland Paleozoic bedrock formations. Common Precambrian Shield lithologies in this area include granite, gneiss, sandstone (including

greywacke) and trap (mafic volcanic/metavolcanic, diabase) with lesser amounts of amphibolite, diorite and gabbro. Minor amounts of iron formation and felsic metavolcanics are also present.

Challenges with this sample included distinguishing between dark grey fine to medium sandstone, which some analysts may have classified as greywacke, and the mafic volcanic/metavolcanic particles present in the sample. There was an additional challenge in correctly assessing the quality of different silicate particles through various techniques, e.g., scratch hardness.

Sample sets consisting of two bags, each containing three separate representative fractions of the coarse aggregate were pre-prepared by MTO and shipped to participants. Fractions contained in each sample bag with approximate amounts are shown in Table 5 below.

Table 5. Individual sample mass supplied for testing

Fraction	Approximate Mass (g)
P19 mm / R13.2 mm	1500
P13.2 mm / R9.5 mm	500
P9.5 mm / R4.75 mm	200
Total Mass	2200

A prescribed gradation for the purposes of calculating the weighted average PN and the weighted average composition of each different rock type identified in the sample was included in the 2015 Proficiency Program instructions provided to each participant. In addition, laboratories were instructed to submit their data on a standardized Excel spreadsheet (PH-CC-343) with built-in calculation functions. Worksheets were submitted by 32 analysts, with each analyst assigned an individual laboratory number. See Appendix E1 for the detailed data summary of all the Petrographic Analysis Test worksheets submitted for 2015.

Eleven laboratories were identified as outliers due to various reasons. Basis for outlier identification is further detailed in the following paragraphs.

Outliers: Calculation Errors, Incomplete Forms and Failure to Follow 2015 Proficiency Instructions

Despite the availability of the standardized PH-CC-343 spreadsheet provided to each participant, 7 laboratories elected to submit their data using an alternate form. These submissions were considered acceptable if their forms contained all the necessary data included in the standardized PH-CC-343 spreadsheet, were completed in full, and did not have calculation errors.

Four laboratories (27, 80, 86 and 350) were excluded from this evaluation as outliers for one or more of the following reasons: Lab 27 did not complete worksheets in full and had calculation errors on worksheet 2.15. Lab 80 used a gradation other than that indicated in the proficiency instructions. Lab 86 submitted incorrectly completed worksheets and used a gradation other than that

indicated in the proficiency instructions. Lab 350 submitted worksheets with calculation errors and used a gradation other than that indicated in the instructions.

Use of a gradation different than the one provided in the 2015 Proficiency Instructions affects the weighted average PN and weighted compositions. Therefore, results from participants that did not use the provided gradation cannot be compared equally with those that used the prescribed gradation.

A summary of the as received petrographic data, after initial removal of Labs 27, 80, 86, and 350 for reasons given above is provided in Table 6.

Table 6. Summary of Petrographic Results, LS-609 (initial labs removed)

Classification	Range %	Median %	Average %	*MTO Petrographer**
Petrographic Number	**102.7 – 157.9**	**115.1**	**116.8**	***132.6***
% Total Siliceous Aggregate	47.7 – 84.8	80.2	79.2	*81.8*
% Total Carbonate Aggregate	15.2 – 52.3	19.8	20.8	*18.2*
% Good Aggregate	**76.5 – 99.0**	**93.6**	**93.5**	***87.8***
% Good Siliceous Aggregate	46.3 – 83.4	77.7	76.3	*74.1*
% Good Carbonate Aggregate	7.9 – 50.8	15.9	17.1	*13.7*
% Fair Aggregate	**0.1 – 20.2**	**5.1**	**5.3**	***9.6***
% Fair Siliceous Aggregate	0 – 15.8	1.6	2.6	*5.9*
% Fair Carbonate Aggregate	0 – 9.9	2.4	2.7	*3.7*
% Poor Aggregate	**0 – 3.0**	**1.2**	**1.1**	***2.5***
% Poor Siliceous Aggregate	0 – 1.9	0.1	0.2	*1.7*
% Poor Carbonate Aggregate	0 – 2.9	0.9	0.9	*0.8*
% Deleterious Aggregate	**0 – 0.6**	**0**	**0**	***0.1***

N = 28 analysts from 21 laboratories, 56 analyses total.
*Results for the average of two samples analysed by the MTO Petrographer are provided for reference. MTO Petrographer results are not included in calculations of range, median and average of the different quality categories and rock type groupings.

Outliers: Rock Type Identification

LS-609 provides, in part, the means for subjective evaluations of rock quality such that a purely statistical analysis of the reported PN values does not fully capture the performance of individual analysts. In order to evaluate a participant's competency with respect to fundamental rock/mineral identification, a statistical analysis on several combinations of key rock types, irrespective of quality classification, was completed. Laboratories that failed to report either the main rock types or key groups of rock types in reasonable quantities, or that reported excessive amounts of particular materials that cannot be reasonably explained by material source variability or sample preparation were identified as outliers.

The following key rock type groupings, based on the general bedrock and surficial geology of the sampled source area, were identified for evaluation:

1) **Carbonate rock types and minerals:** Total weighted composition of rock types 1, 20, 2, 21, 23, 35, 41, 42, 40, 26, 43, 44, 45, and 64 combined. The chert-containing carbonate rock types 5, 26 and 45 were included as carbonates.

2) **Siliceous rock types and minerals:** Total weighted composition of rock types 3, 22, 6, 4, 5, 8, 7, 9, 10, 11, 71, 81, 30, 29, 52, 25, 34, 27, 28, 82, 46, 56, 53, 50, 55, 51, 48, 84, 60, 61, 62, and 63. Other siliceous rock types separately identified by analysts were also included: orthoquartzite, metasedimentary, and metavolcanic.

3) **Granite-Diorite-Gabbro and Gneiss-Amphibolite-Schist rock types:** Total weighted composition of rock type numbers 8, 6, 25, 27, 50, 55, 51 and 63.

4) **Trap rock and Volcanic rock types:** Total weighted composition of rock types 7, 9, 28, 48, 63 and the "metavolcanic" rock type separately identified by one analyst.

5) **Clastic Sedimentary rock types:** Total weighted composition of the rock types. Includes rock type numbers 3, 22, 5, 30, 29, 34, 46, 56, 61. Includes orthoquartzite and metasedimentary rock types identified separately by individual analysts.

6) **Combined Trap rock, Volcanic and Clastic Sedimentary rock types:** Total weighted compositions of classed materials 4) and 5) above combined. This combination was included after it became apparent that some analysts had difficulty distinguishing between the dark grey fine grained sandstone (greywacke) and the dark grey-green finely crystalline-to aphanitic trap rock (mafic volcanic/metavolcanic). Where amounts of one were incorrectly identified as the other, the reported amounts of the combined rock types should be similar.

Graphical representations of the significant rock type Groupings examined in detail are included in Figures 2 to 7.

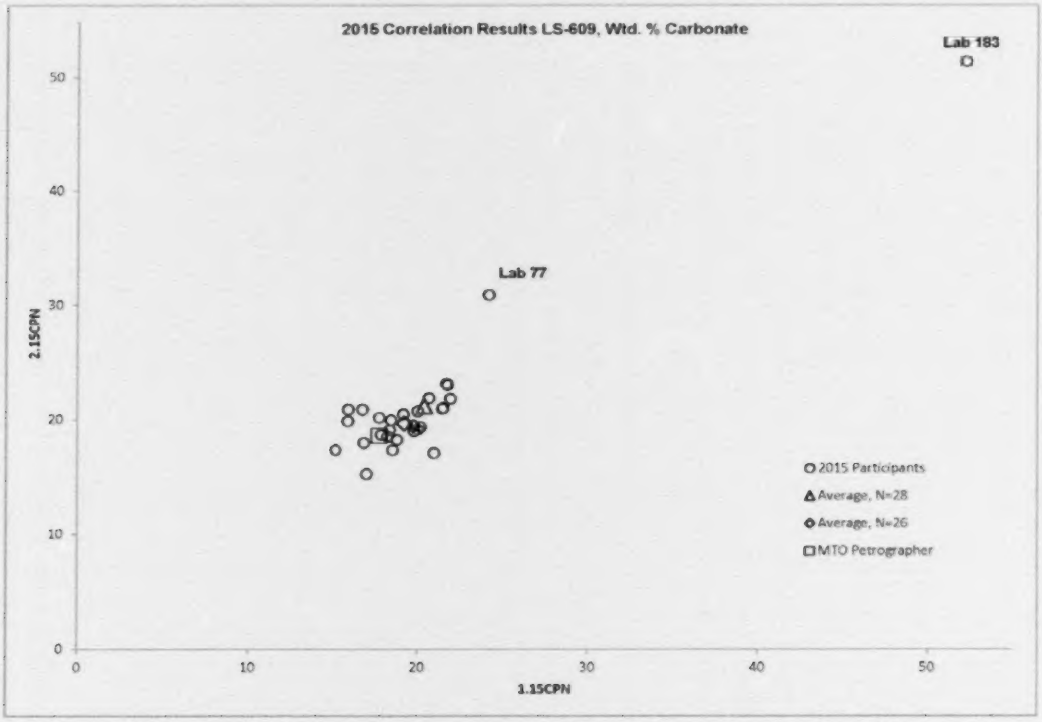


Figure 2. Carbonate rock types and minerals, total weighted composition, % (N=28)

Carbonate rock types and minerals, total weighted composition (%).		
N=26 (outliers excluded)	**1.15CPN**	**2.15CPN**
Minimum	15.2	15.2
Maximum	24.2	23.1
Average	19.2	19.6
Median	19.3	19.6
Standard Deviation	2.188	1.858
Labs Eliminated	**183, 77**	

Labs 183 and 77 were eliminated as outliers by Iterative Technique. The divergence of reported values indicates difficulty in the correct geological identification of carbonate versus siliceous rock types, irrespective of quality. The combined total range of both samples in the carbonate rock types and minerals grouping after eliminating outliers is 15.2% to 24.2%, average of 19.4%.

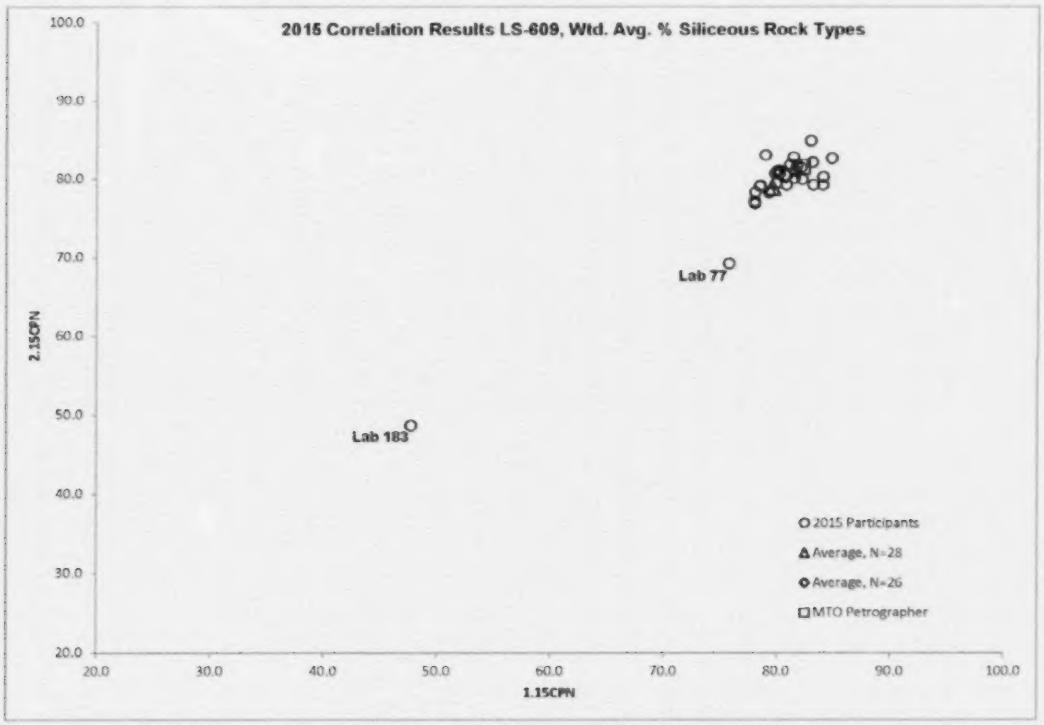


Figure 3. Siliceous rock types and minerals, total weighted composition, % (N=28)

Siliceous rock types and minerals, total weighted composition (%)		
N=26 (outliers excluded)	1.15CPN	2.15CPN
Minimum	75.8	76.8
Maximum	84.8	84.8
Average	80.7	80.4
Median	80.9	80.4
Standard Deviation	2.208	1.866
Labs Eliminated	**183, 77**	

Labs 183 and 77 were eliminated as outliers by Iterative Technique. The divergence of reported values indicates difficulty in the correct geological identification of carbonate versus siliceous rock types irrespective of quality. The combined total range of both samples in the siliceous rock types and minerals grouping after eliminating outliers is 75.8% to 84.8%, average of 80.6%.

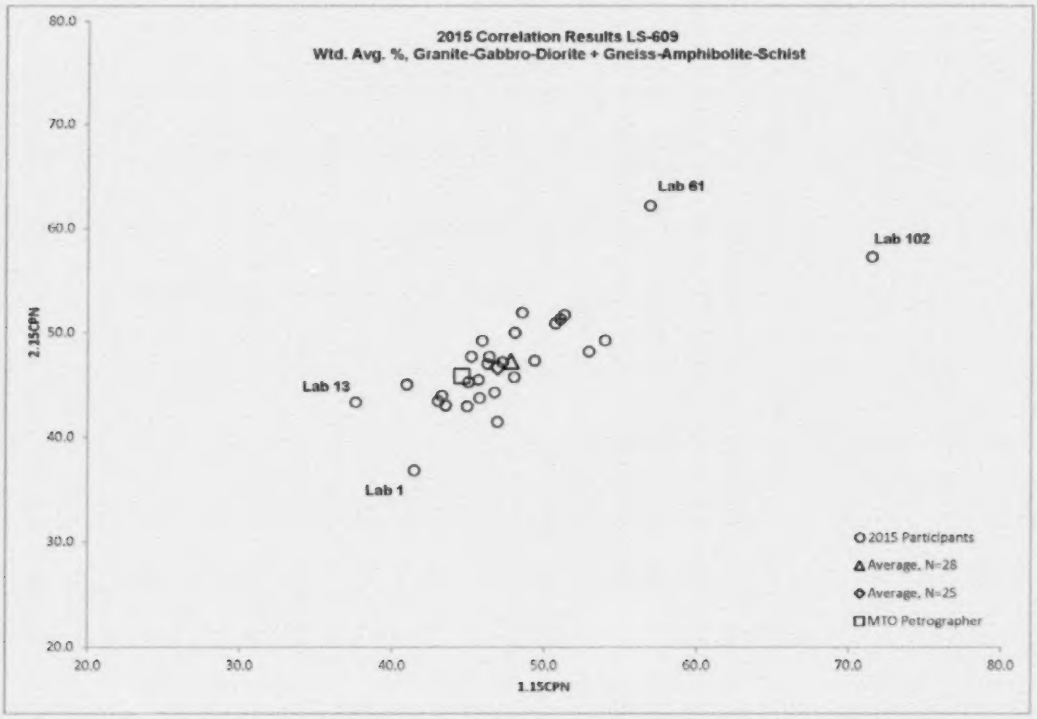


Figure 4. Granite-Diorite-Gabbro and Gneiss-Amphibolite-Schist, total weighted composition, % (N=28)

Granite-Diorite-Gabbro and Gneiss-Amphibolite-Schist, total weighted composition (%).		
N=25(outliers excluded)	**1.15CPN**	**2.15CPN**
Minimum	37.6	41.4
Maximum	56.9	51.9
Average	46.9	46.6
Median	46.4	46.9
Standard Deviation	4.181	3.067
Labs Eliminated	**1, 61, 102**	

Labs 1, 61, and 102 were eliminated as outliers by Iterative Technique. The combined total range of both samples in the Granite-Diorite-Gabbro and Gneiss-Amphibolite-Schist rock types grouping after eliminating outliers is 37.6% to 56.9%, average of 46.8%.

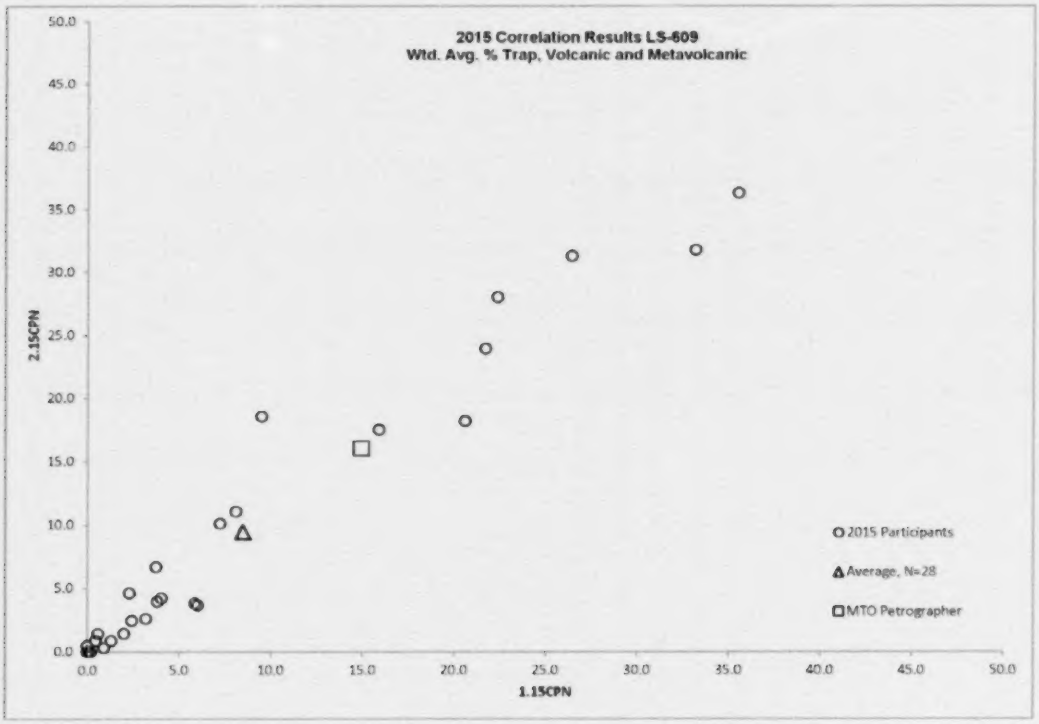


Figure 5. Traprock and Volcanic rock types, total weighted composition, % (N=28)

Traprock and Volcanic rock types, total weighted composition, %		
N=28	1.15CPN	2.15CPN
Minimum	0	0
Maximum	35.5	36.3
Average	8.5	9.4
Median	3.8	3.9
Standard Deviation	10.622	11.422
Labs Eliminated	**None**	

No labs were eliminated as outliers by Iterative Technique. The plot shows a pronounced between-laboratory bias as well as a similar amount of variation for each material. The combined total range of both samples in the traprock and volcanic rock types grouping is 0.0% to 36.3%, average of 9%.

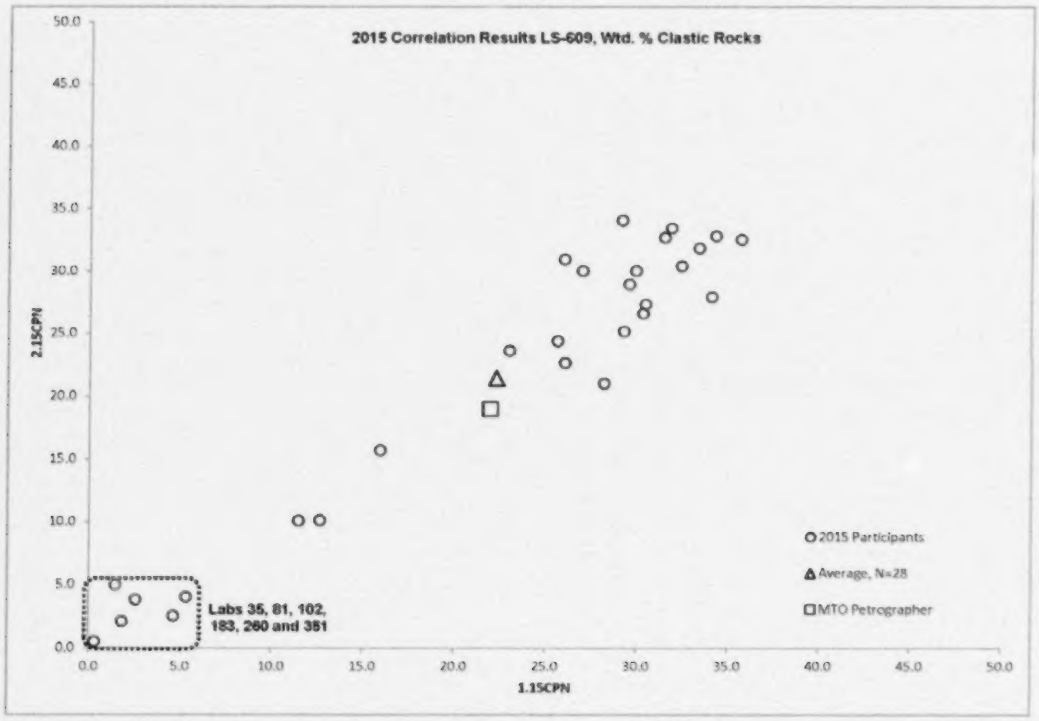


Figure 6. Clastic Sedimentary rock types, total weighted composition, % (N=28)

Clastic Sedimentary rock types, total weighted composition, %		
N=28	1.15CPN	2.15CPN
Minimum	0.3	0.5
Maximum	35.7	34.0
Average	22.3	21.4
Median	27.6	25.9
Standard Deviation	11.980	11.607
Labs Eliminated	**None**	

No labs were eliminated as outliers by Iterative Technique. The plot shows a pronounced between-laboratory bias as well as a similar amount of variation for each material. The combined total range of both samples in the clastic sedimentary rock types grouping is 0.3% to 35.7%, average of 21.9%.

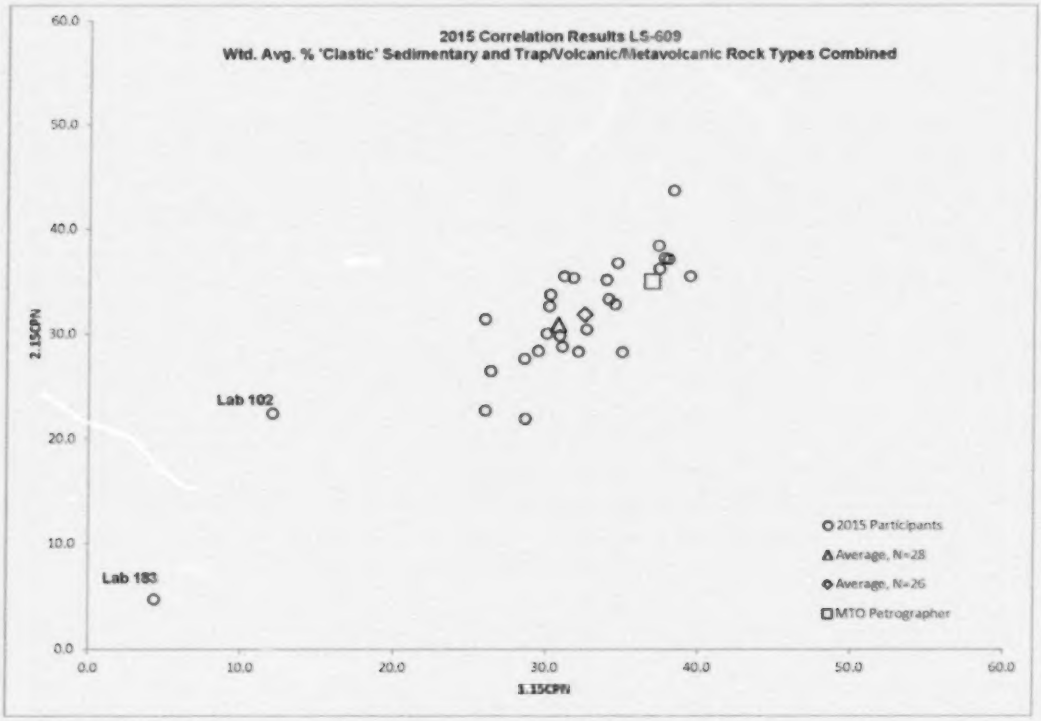


Figure 7. Combined Traprock, Volcanic and Clastic Sedimentary rock types, total weighted composition, % (N=28)

Combined Traprock, Volcanic and Clastic Sedimentary rock types, total weighted composition, %		
N=26 (outliers excluded)	**1.15CPN**	**2.15CPN**
Minimum	26.0	21.9
Maximum	39.4	43.7
Average	32.5	31.8
Median	31.9	32.6
Standard Deviation	3.953	5.248
Labs Eliminated	**183, 102**	

Labs 183 and 102 were eliminated as outliers by Iterative Technique. The combined total range of both samples in the combined traprock, volcanic and clastic sedimentary rock types grouping after eliminating outliers is 21.9% to 43.7%, average of 32.2%.

Outliers: Quality Classification

Test results were evaluated on the basis of quality classification as well as a combination of rock type and quality. Categories used in this evaluation were:

1) Weighted Average Petrographic Number (PN),
2) Petrographic Number (PN), individual fractions
3) Good Aggregate, Total
4) Fair Aggregate, Total
5) Good Aggregate, siliceous rock types
6) Fair Aggregate, siliceous rock types
7) Good Aggregate, carbonate rock types
8) Fair Aggregate, carbonate rock types

Statistical analyses were completed on each of these categories to identify outliers. Graphical representations of the results and laboratories identified as outliers are summarized in Figures 8 to 17.

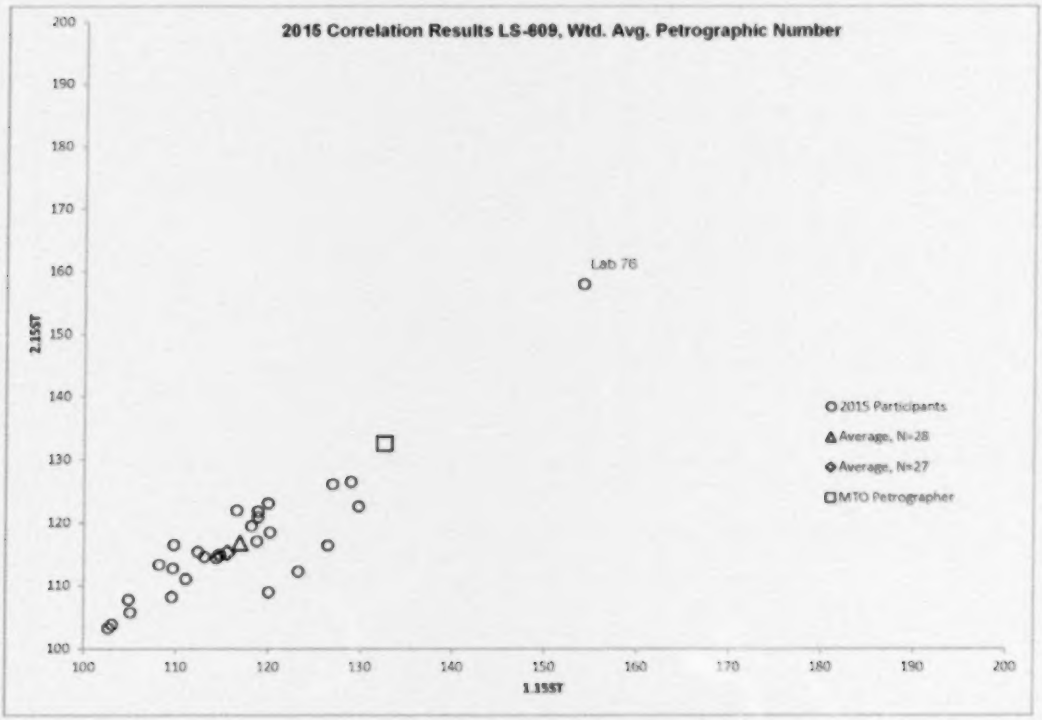


Figure 8. Weighted Average Petrographic Number (PN) (N = 28)

Weighted Average Petrographic Number (PN),		
N=27	**1.15CPN**	**2.15CPN**
Minimum	102.7	103.2
Maximum	129.8	126.4
Average	115.6	115.2
Median	114.8	114.8
Standard Deviation	7.686	6.377
Labs Eliminated	**76**	

Lab 76 was eliminated as outlier by Iterative Technique. The combined total range of both samples in the weighted average Petrographic Number (PN), category after eliminating outliers is 102.7 to 129.8, average of 115.4.

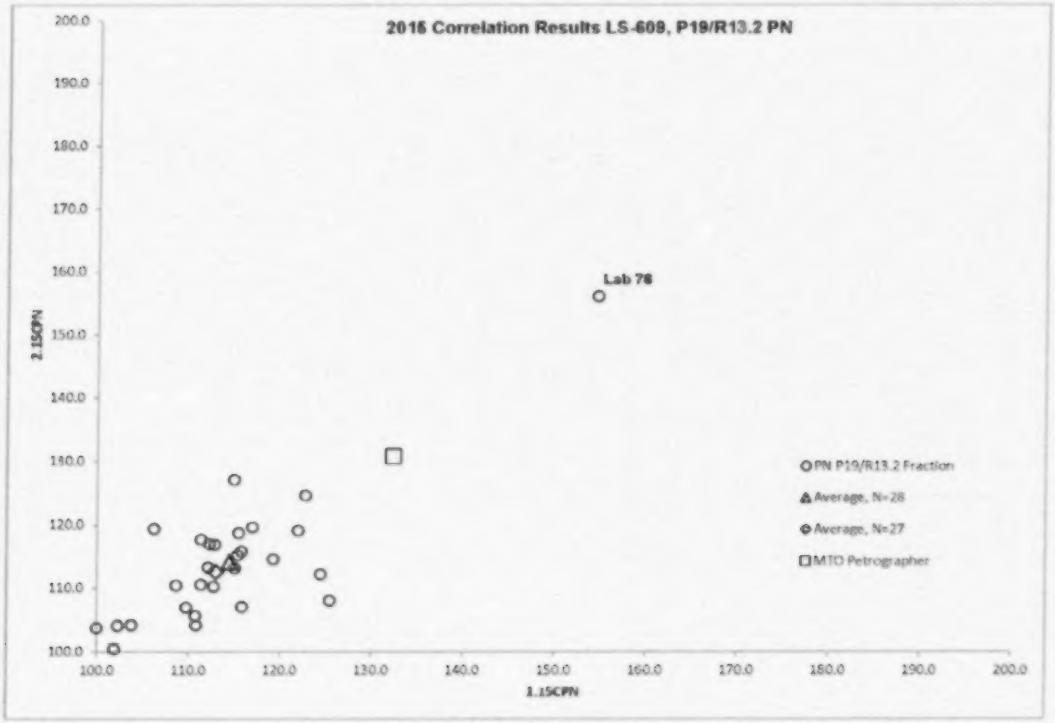


Figure 9. Petrographic Number (PN), individual fraction: P19/R13.2 (N = 28)

PN: P19/R13.2 Fraction		
N=27	1.15CPN	2.15CPN
Minimum	100	100.4
Maximum	125.5	127
Average	113	112.5
Median	112.9	113.1
Standard Deviation	6.621	6.782
Lab Eliminated	**76**	

Lab 76 was eliminated as outlier by Iterative Technique. The combined total range of both samples in the P19/R13.2 fraction after eliminating the outliers is 100 to 127, average of 113.

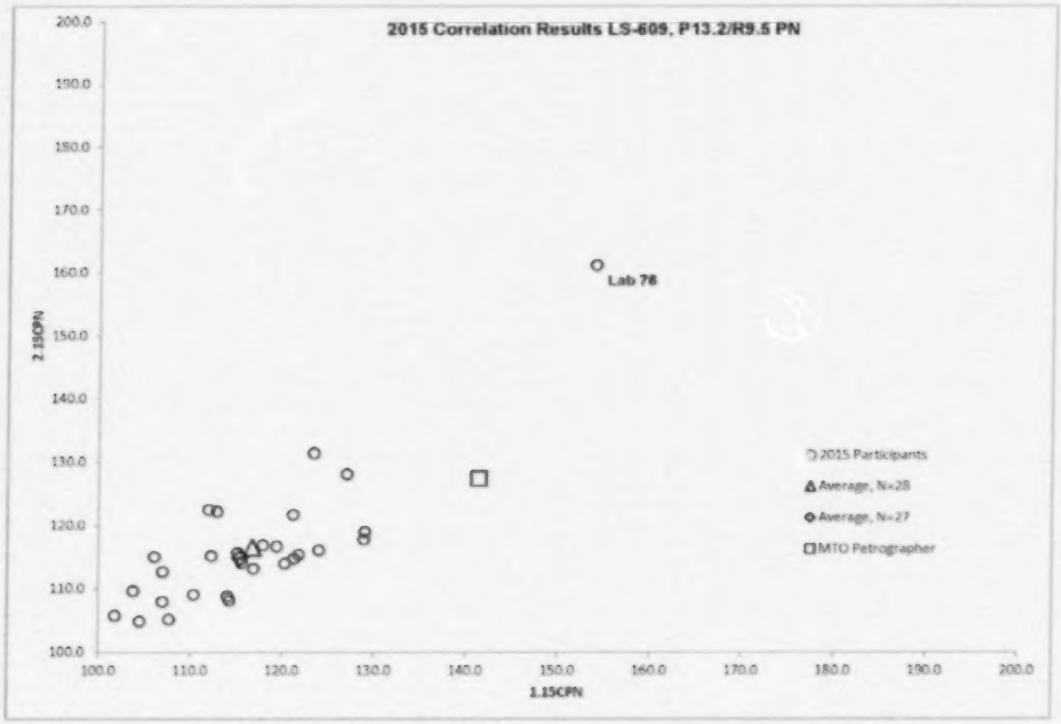


Figure 10. Petrographic Number (PN), individual fraction: P13.2/R9.5 (N = 28)

PN: P13.2/R9.5 Fraction		
N=27	1.15CPN	2.15CPN
Minimum	101.8	104.8
Maximum	129	131.3
Average	115.4	114.8
Median	115.2	115
Standard Deviation	7.792	6.548
Lab Eliminated	**76**	

Lab 76 was eliminated as outlier by Iterative Technique. The combined total range of both samples in the P13.2/R9.5 fraction after eliminating outliers is 101.8 to 131.3, average of 115.1.

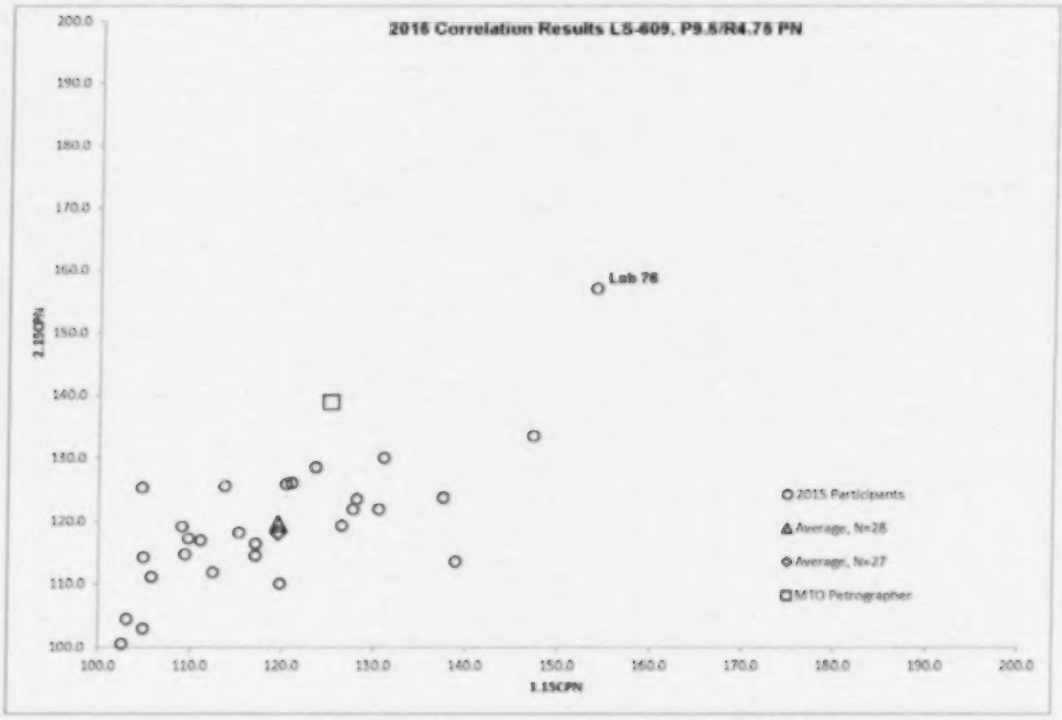


Figure 11. Petrographic Number (PN), individual fraction: P9.5/R4.75 (N = 28)

PN: P9.5/R4.75 Fraction		
N=27	1.15CPN	2.15CPN
Minimum	102.6	100.5
Maximum	154.0	133.5
Average	119.6	118.1
Median	117.1	118.6
Standard Deviation	13.61	8.21
Lab Eliminated	**76**	

Lab 76 was eliminated as outlier by Iterative Technique. The combined total range of both samples in the P9.5/R4.75 fraction after eliminating outliers is 100.5 to 154.0, average of 118.9.

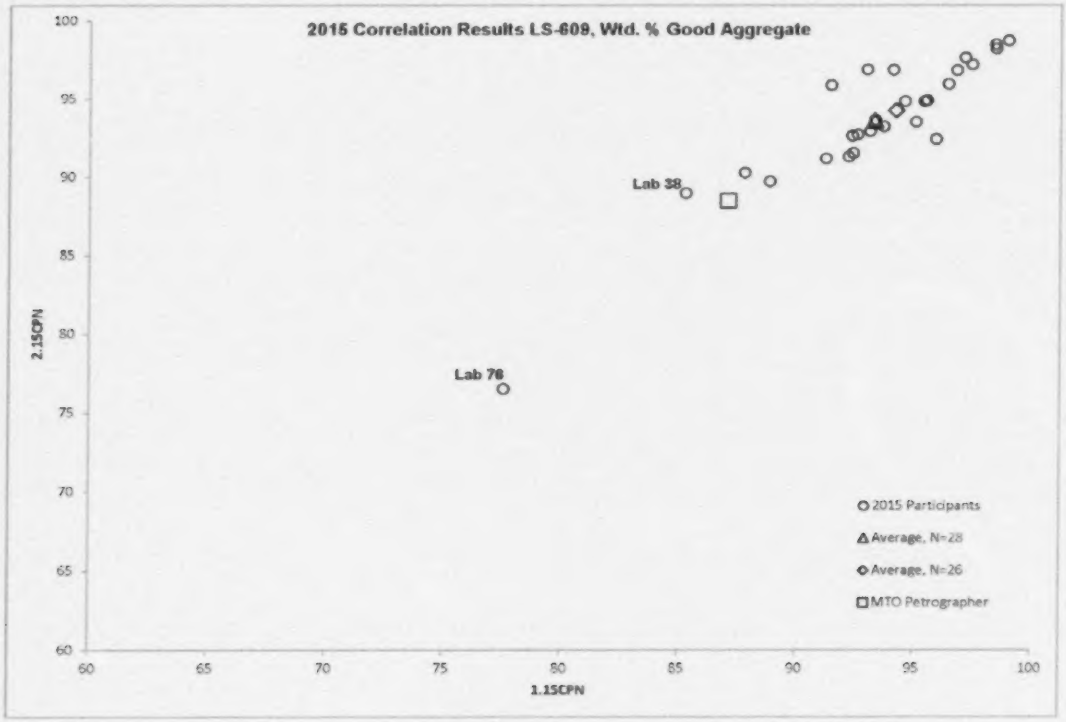


Figure 12. Total Good Aggregate, weighted average % (N = 28)

Total Good Aggregate, weighted average %		
N=26	1.15CPN	2.15CPN
Minimum	87.8	88.9
Maximum	99.0	98.7
Average	94.2	94.2
Median	93.9	93.6
Standard Deviation	2.835	2.794
Labs Eliminated	**76, 38**	

Labs 76 and 38 were eliminated as outliers by Iterative Technique. The combined total range of both samples in the Total Good Aggregate category after eliminating outliers is 87.8% to 99.0%, average of 94.2%.

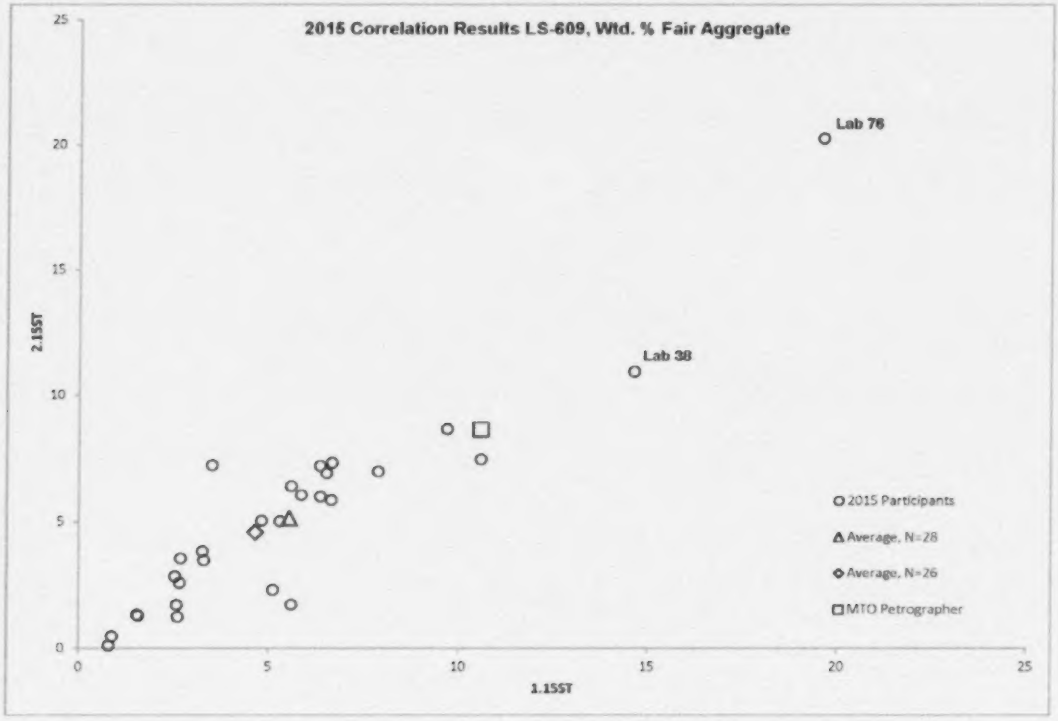


Figure 13. Total Fair Aggregate, weighted average % (N = 28)

Total Fair Aggregate, weighted average %		
N=26	1.15CPN	2.15CPN
Minimum	0.8	0.1
Maximum	10.6	10.9
Average	4.7	4.3
Median	5.0	4.4
Standard Deviation	2.582	2.833
Labs Eliminated	**76, 38**	

Labs 76 and 38 were eliminated as outliers by Iterative Technique. The combined total range of both samples for the Total Fair Aggregate category after eliminating outliers is 0.1% to 10.6%, average of 4.5%.

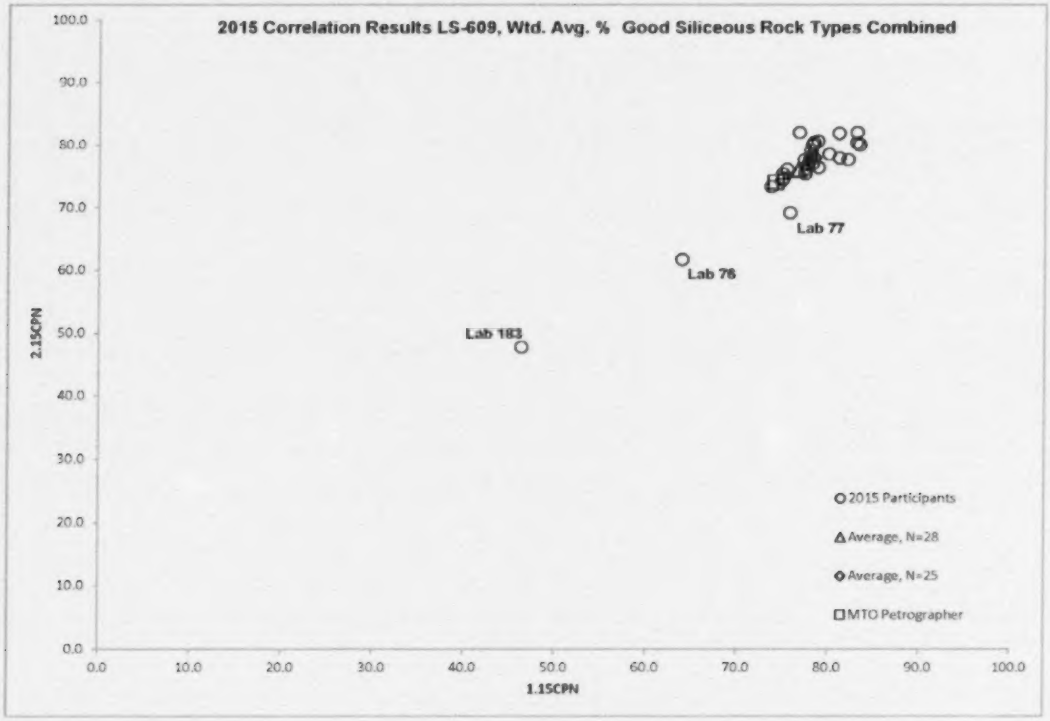


Figure 14. Good Aggregate, Siliceous Rock Type, weighted average, % (N = 28)

Good Aggregate, Siliceous Rock Type, weighted average %		
N=25	1.15CPN	2.15CPN
Minimum	73.7	73.3
Maximum	83.4	82.0
Average	78.3	78.0
Median	78.0	77.7
Standard Deviation	2.691	2.460
Labs Eliminated	**76, 77, 183**	

Labs 76, 77 and 183 were eliminated as outliers by Iterative Technique. The combined total range of both samples for Good Aggregate, Siliceous Rock Type category after eliminating outliers is 73.3% to 83.4%, average of 78.1%.

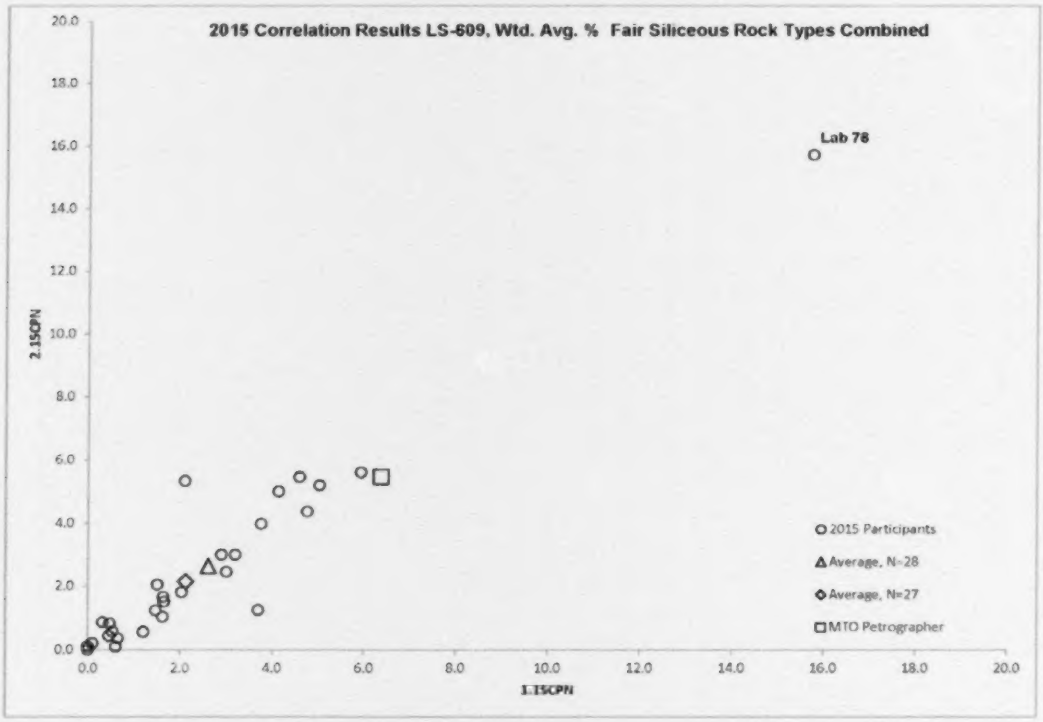


Figure 15. Fair Aggregate, Siliceous Rock Type, weighted average % (N = 28)

Fair Aggregate, Siliceous Rock Type, weighted average %		
N=27	**1.15CPN**	**2.15CPN**
Minimum	0	0
Maximum	5.9	5.6
Average	2.1	2.1
Median	1.6	1.5
Standard Deviation	1.743	1.912
Lab Eliminated	**76**	

Lab 76 was eliminated as outlier by Iterative Technique. The combined total range of both samples in the Fair Aggregate, Siliceous Rock Type category after eliminating outliers is 0% to 5.9%, average of 2.1%.

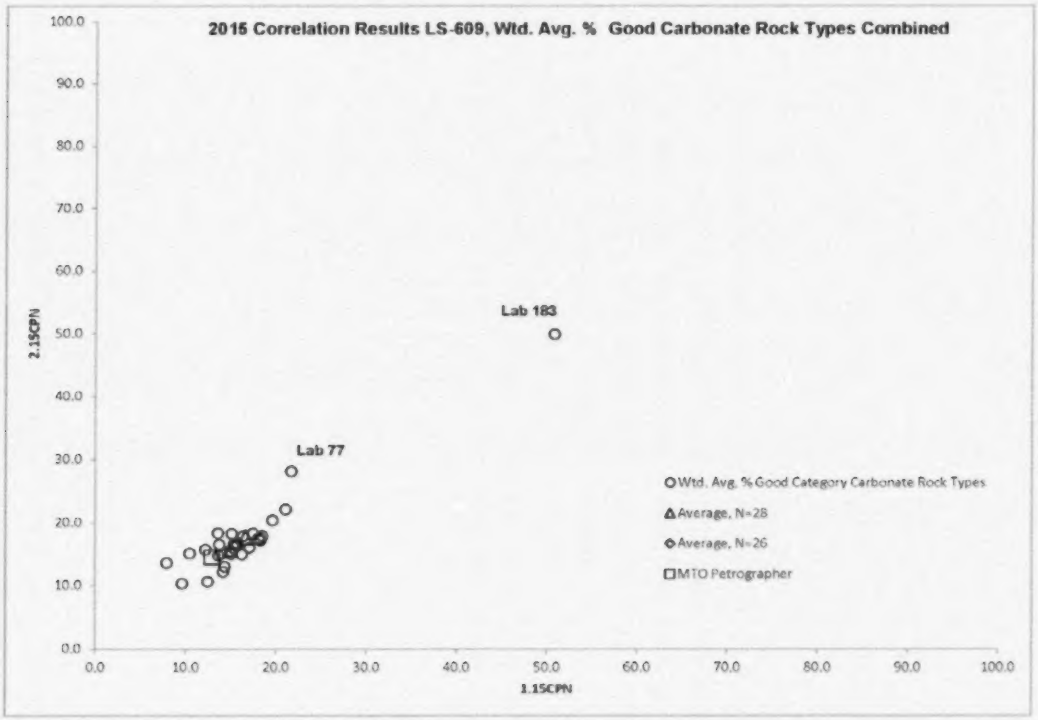


Figure 16. Good Aggregate, Carbonate Rock Type, weighted average % (N = 28)

Good Aggregate, Carbonate Rock Type, weighted average %		
N=26	**1.15CPN**	**2.15CPN**
Minimum	7.9	10.3
Maximum	21.7	22.0
Average	15.4	16.0
Median	15.1	16.0
Standard Deviation	3.273	2.682
Lab Eliminated	**77, 183**	

Labs 77 and 183 were eliminated as outliers by Iterative Technique. The combined total range of both samples in the Good Aggregate, Carbonate Rock Type category after eliminating outliers is 7.9% to 22.0%, average of 15.7%.

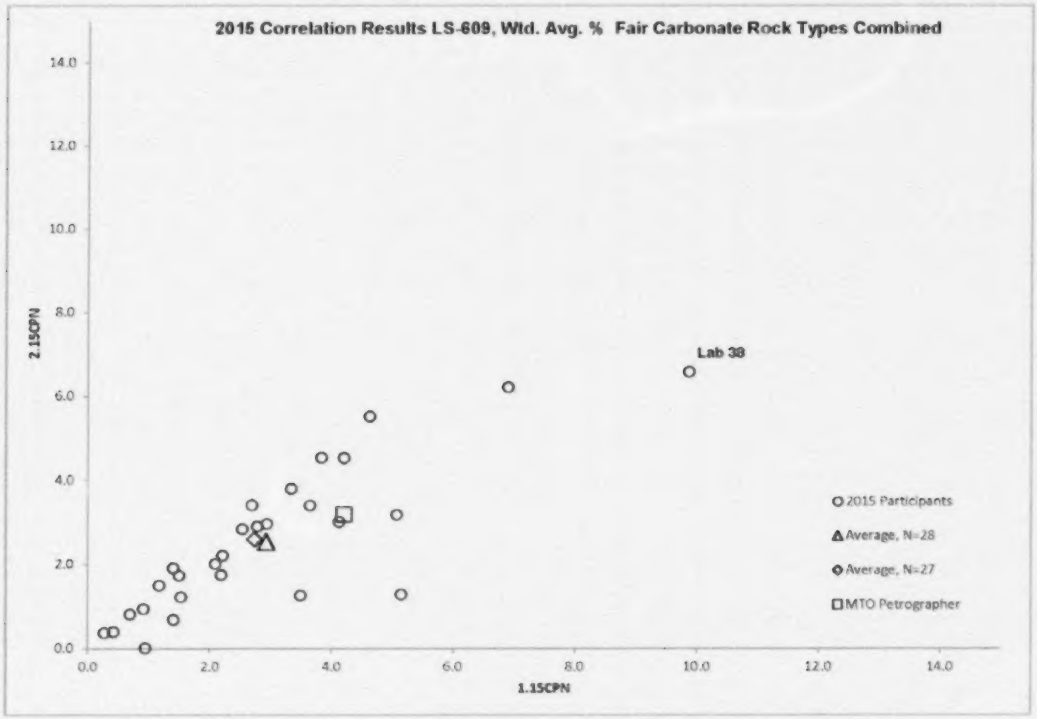


Figure 17. Fair Aggregate, Carbonate Rock Type, weighted average % (N = 27)

Fair Aggregate, Carbonate Rock Type, weighted average %		
N=27	**1.15CPN**	**2.15CPN**
Minimum	0.3	0
Maximum	6.9	6.6
Average	2.7	2.5
Median	2.5	2.1
Standard Deviation	1.655	1.760
Lab Eliminated	**38**	

Lab 38 was eliminated as outlier by Iterative Technique. The combined total range of both samples in the Fair Aggregate, Carbonate Rock Type category after eliminating outliers is 0% to 6.9%, average of 2.6%.

Summary

A total of 11 laboratories were eliminated as outliers for 2015. These were Labs 1, 27, 38, 61, 76, 77, 80, 86, 102, 183, and 350. Table 7 is a summary of the laboratories identified as outliers and the basis for the decision.

Table 7. Summary of laboratories identified as outliers

Laboratory	Details
1	Identified as outlier by Iterative Technique. Lab eliminated due to significant deviation from population in specific rock type groups. See Figure 3.
27	Eliminated as outlier due to incomplete worksheets and calculation errors on worksheet 2.15.
38	Identified as outlier by Iterative Technique. Lab eliminated due to significant deviation from population in determination of quality classification. See Figures 11 and 12.
61	Identified as outlier Iterative Technique. Lab eliminated due to significant deviation from population in specific rock type groups. See Figure 3.
76	Identified as outlier by Iterative Technique. Lab eliminated due to significant deviation from population in quality classification of materials. See Figures 7 to 14.
77	Identified as outlier by Iterative Technique. Lab eliminated due to incorrect rock identification. Difficulty in identifying carbonate versus silicate rock types, see Figures 1, 2, 13 and 14.
80	Eliminated as outlier. Failure to follow 2015 Proficiency Instructions: did not use prescribed gradation.
86	Eliminated as outlier. Failure to follow 2015 Proficiency Instructions: did not use prescribed gradation. Worksheets completed incorrectly.
102	Identified as outlier by Iterative Technique. Eliminated due to significant deviation from population in specific rock type groups. See Figures 3 and 6. Did not identify any significant amount of the clastic sedimentary rock groups which formed a large component of the materials provided (Figure 5).
183	Identified as outlier by Iterative Technique. Lab eliminated due to incorrect rock identification. Difficulty in identifying carbonate versus silicate rock types, see Figures 1 and 2. Also see Figure 6. Did not identify any significant amount of the clastic sedimentary rock groups which formed a large component of the materials provided (Figure 5).
350	Eliminated as outlier. Failure to follow 2015 Proficiency Instructions: did not use prescribed gradation. Calculation errors.

The 2015 data highlights the need for additional training of analysts with respect to both rock identification and quality classification. Failure to identify key rock types and groups of rock types, in particular the inability to identify siliceous versus carbonate rock types is considered a serious failure in performing this test method. Many of the plots show very strong laboratory bias particularly with respect to quality classification (Figures 8-13 and 15-17), but also with respect to particular rock types and groups of rock types, e.g., identification of 'greywacke' versus 'trap' and/or 'volcanic' (Figures 5 and 6). There is also a clear need for more frequent communication and interaction between analysts in the petrographic community. More frequent interaction and feedback may help to reduce some of the variability and in particular the strong laboratory bias observed with respect to quality classification.

Labs that did not report significant amounts of the clastic sedimentary rock types that formed a large component of the materials provided should critically re-examine their samples. In particular Labs 35, 81, 102, 183, 260 and 351 are strongly encouraged to do so (Figure 6). Although no statistical outliers could be determined in this rock types grouping due to the strong laboratory bias (Figure 6), well experienced analysts were generally found to report approximate ranges of ~10-30% for the clastic sedimentary rock types. Correctly distinguishing between greywacke' versus 'trap' and/or 'mafic volcanic' (Figures 5, 6 and 18) is the most likely source of the observed bias. Several analysts may have classed the dark grey fine grained sandstone (greywacke) with the Conglomerate-Sandstone-Arkose rock types (rock type numbers 3, 22, 30, and 46). This cannot be faulted, as 'greywacke' by definition is a specific type of sandstone.

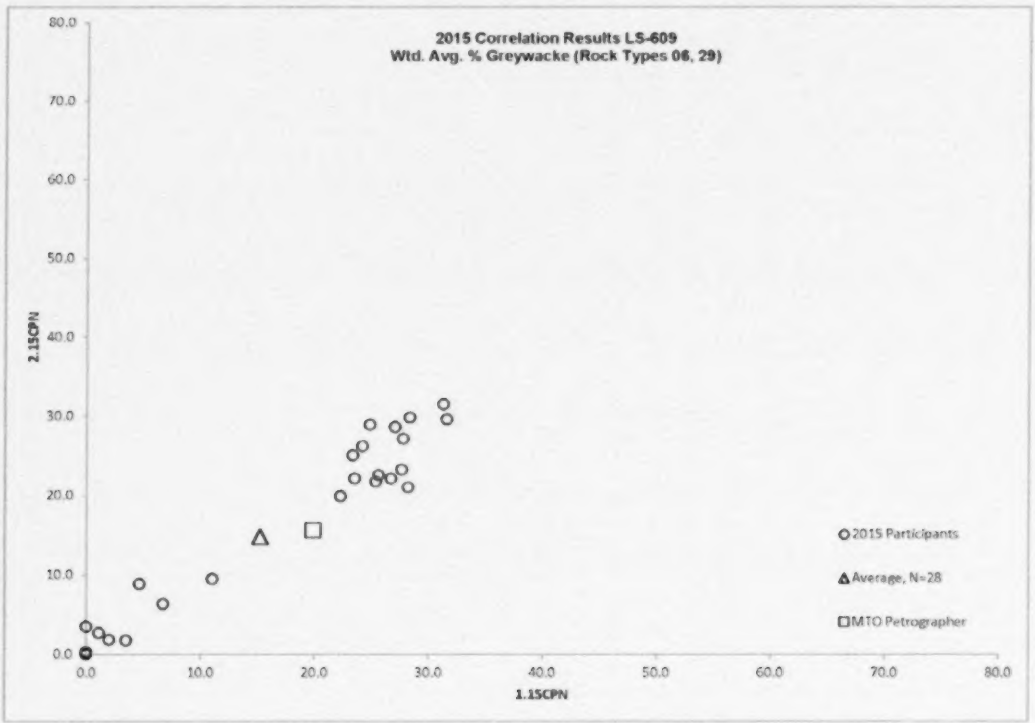


Figure 18. Greywacke Rock Types 6 and 29 combined, weighted average % (N = 28)

No statistical analysis completed for outlier identification. The plot shows a pronounced between-laboratory bias as well as a similar amount of variation for each material.

A summary of the petrographic results after removal of all outlier laboratories from the data set is included in Table 8.

Table 8. Summary of LS-609 Results after removal of all outlier labs

	Range	Median	Average
Weighted Average Petrographic Number (PN)	102.7 - 129	115.8	116
Good Aggregate, %	87.8 - 99	93.5	93.9
Fair Aggregate, %	0.1 – 10.6	5.2	4.9
Poor Aggregate, %	0 – 3.0	1.3	1.2
Deleterious Aggregate, %	0 – 0.4	0	0
Total Siliceous Rock Types, %	76.8 – 84.0	80.2	80.3
Total Carbonate Rock Types, %	16 – 23.1	19.8	19.7
Good Aggregate, Siliceous Rock Types, %	73.3 – 83.1	77.8	77.9
Good Aggregate, Carbonate Rock Types, %	9.6 - 22	16.1	16.0
Fair Aggregate, Siliceous Rock Types, %	0 – 5.9	1.6	2.2
Fair Aggregate, Carbonate Rock Types, %	0.4 – 6.9	2.2	2.7
Poor Aggregate, Siliceous Rock Types, %	0 – 0.8	0.1	0.2
Poor Aggregate, Carbonate Rock Types, %	0 – 2.9	1.1	1.0
Total Granite-Gneiss-Amphibolite and Granite-Diorite-Gabbro Rock Types (4, 8, 25, 27, 50, 51), %	37.6 – 54.0	46.1	46.6
Total Clastic Sedimentary Rock Types (3, 22, 6, 5, 30, 29, 34, 46, 56, 61, orthoquartzite, metasedimentary rock), %	1.5 – 35.7	29	23.1
Total Traprock and Volcanic Rock Types (7, 9, 28, 48, 63, metavolcanic), %	0 – 36.3	3.8	9.7
Total Traprock, Volcanic and Clastic Sedimentary Rock Types, %	26.0 – 39.4	32.6	32.8
Total Greywacke Rock Types (6, 29), %	0 – 31.6	21.9	14.7
Total Chert-Bearing Rock Types (21, 26, 45), %	0.1 – 5.4	2.5	2.5
Total Fair and Poor Aggregate, Chert-Bearing Rock Types (26, 45), %	0 – 4.9	2.1	1.9
Petrographic Number, P19/R13.2 Fraction	100 – 125.5	113.2	113.1
Petrographic Number, P13.2/R9.5 Fraction	103.8 – 131.3	115.2	116.0
Petrographic Number, P9.5/R4.75 Fraction	100.5 – 147.3	118.6	118.9

N = 21 analysts, 46 analyses total.

Additional test results completed by MTO on this material prior to choosing it for the 2015 Sample Test Proficiency Program are provided below.

MTO Test Method	Test Result
LS-604 Absorption	0.99%
LS-605 Bulk Relative Density	2.649
LS-606 $MgSO_4$ Soundness	3%
LS-614 Freeze-Thaw Loss	2.26%
LS-618 Micro-Deval Abrasion	7.5%
LS-620 Accelerated Mortar Bar	0.276%

The similar standard ASTM C 295, Standard Guide for Petrographic Examination of Aggregates for Concrete, does not report a Petrographic Number (PN) and has no precision statement.

3.4.9 LS-616 - Petrographic Examination (Fine Aggregate)

The fine aggregate examined in 2015 was concrete sand from a pit source in the Stouffville area, north of Toronto. This is same material that was used for insoluble residue test numbers 15 and 98, and accelerated mortar bar test number 123. Historical petrographic data for sources located in this area of the Oak Ridges Moraine indicate petrographically determined carbonate rock and mineral contents of approximately 50% to 60%. The remainder of the balance is historically typically composed of silicate rocks and minerals with minor amounts of chert and mica.

Twelve analysts from 5 laboratories submitted worksheets showing subdivision according to rock/mineral type for samples 1.15FPN and 2.15FPN. As some laboratories had multiple analysts, for the purpose of this report, each analyst is assigned an individual laboratory number. Each analyst is referred to by their laboratory number. Please see Appendix E2 for the detailed summary of all the fine aggregate petrographic worksheets submitted for 2015.

For 2015, carbonate content was chosen as the key rock and/or mineral type to evaluate participant's abilities. Identification of carbonate versus silicate rock or mineral type is a basic fundamental aspect of petrographic analysis. Statistical analysis was performed on reported carbonate contents for each sieve fraction to identify outliers. Lab 152 was the only laboratory statistically identified as an outlier for weighted average carbonate (Figure 19). A summary of carbonate contents reported for each sieve fraction, as well as the overall weighted average, after removal of the outlier is summarized in Table 9.

As a cross-check, MTO also completed LS-613, insoluble residue testing (IR) on individual fractions and on five representative samples. (The IR test indirectly determines the amount of carbonate minerals, which are dissolved when exposed to a hydrochloric acid solution. After complete digestion, the remaining residue consists of the non-carbonate components of the sample.) Results of the IR testing are summarized in Table 10.

In general, the IR data correlates well with the averages of the petrographic carbonate contents for individual fractions. However the relatively wide range in reported carbonate contents for each fraction is concerning. Analysts that reported low amounts of carbonate or values that deviated significantly on either side of the averages and/or the amounts indicated by the insoluble residue testing should re-examine their samples, in particular on coarser sieve fractions as the carbonate rock types present should have been readily identified. In general, results from Laboratories 152. 15 and 88 tended to deviate from the averages more than other labs, although 15 and 88 were not statistically identified as outliers.

Several laboratories did not report the minus 75 µm fraction of the gradation. Participants are reminded that for the purpose of calculating the weighted

percent of components, the minus 75 µm fraction needs to be included, (assumed to have the same composition as the retained 75 µm sieve fraction).

The similar ASTM standard for this test, C-295, has no precision statement.

Table 9. Petrographic Results for Carbonate Content (LS-616), N=11 (1 outlier removed)

Carbonate Content – Weighted Average Total Sample				
Fraction	**Range %**	**Median %**	**Average %**	***MTO Petrographer***
P4.75	33.4 – 61.1	49.1	49.0	*59.3*
Carbonate Content – Individual Sieve Fractions				
Fraction	**Range %**	**Median %**	**Average %**	***MTO Petrographer***
P4.75/R2.36	59.5 - 85	77.8	76.0	*78.0*
P2.36/R1.18	48 - 84	72.3	70.4	*63.5*
P1.18/R600	37.2 – 71.5	57.8	57.3	*79.5*
P600/R300	23.5 - 55	40	39.8	*51.5*
P300/R150	20 – 40.5	26.5	27.8	*39.0*
P150/R75	7.7 - 30	17.5	18	*24.5*

MTO Petrographer results (average of two samples) provided for reference.

Table 10. Results of Insoluble Residue Testing (LS-613), completed on the sand used for fine aggregate petrographic examination

Insoluble Residue Results – Average of 5 Representative Samples Tested					
Fraction	**Mass Tested (g)**	**IR_T %**	**IR_{75} %**	**CIR_T %**	**CIR_{75} %**
P4.75	~120g X 5 = ~600g	48.4	44.75	**51.9**	**55.25**
Insoluble Residue Results – Individual Sieve Fractions					
Fraction	**Mass Tested (g)**	**IR_T %**	**IR_{75} %**	**CIR_T %**	**CIR_{75} %**
P4.75/R2.36	~120 g	23.6	24	**73.7**	**76**
P2.36/R1.18	~120 g	27.1	23.9	**72.9**	**76.1**
P1.18/R600	~120 g	38.3	35.7	**61.7**	**64.3**
P600/R300	~120 g	57.2	55.2	**42.8**	**44.8**
P300/R150	~120 g	68.3	66.3	**31.7**	**33.7**
P150/R75	~120 g	69.6	67.3	**30.4**	**32.7**

IR_T = Total Insoluble Residue. IR_{75} = Insoluble Residue Retained on the 75µm sieve. CIR_T = Carbonate Content determined by subtracting IR_T from 100 percent. CIR_{75} = Carbonate Content determined by subtracting IR_{75} from 100 percent.

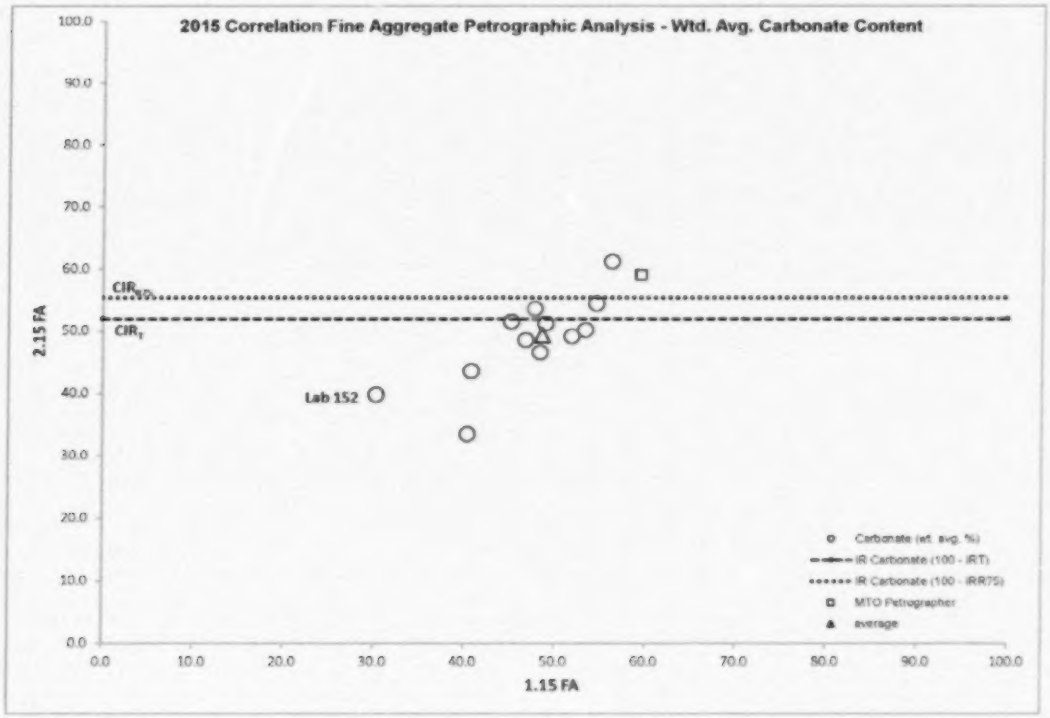


Figure 19. Weighted average % carbonate rock and mineral types (N = 12)

Lab 152 was eliminated as outlier by Iterative Technique.

Weighted Average Carbonate Rock and Minerals , LS-616		
N=11	1.15FPN	2.15FPN
Minimum	40.4	33.4
Maximum	56.3	61.1
Average	**48.6**	**49.3**
Median	48.4	50.1
Standard Deviation	5.224	6.965
Labs Eliminated	**152**	

3.4.10 LS-613 - Total Percentage of Insoluble Residue – Test No. 15 and Percentage of Insoluble Residue Retained 75 µm – Test No. 98

MTO LS-613 is similar to ASTM D3042, insoluble residue in carbonate aggregates, but the scope and procedure to determine the total percentage of insoluble residue and percentage of insoluble residue retained 75µm in LS-613 differ from that of ASTM. In addition, mass and the maximum size of the aggregates recommended for the test sample in LS-613 differ from D3042.

Only fourteen laboratories reported results for this test. Iterative technique was used to remove outliers from both sets of data, i.e., data for Test Nos. 15 and 98. Two outliers from the data for total percentage of insoluble residue and one outlier from the results for percentage of residue retained 75 µm were removed. Majority of the data points on the scatter diagrams are accounted in the lower left and upper right quadrants indicating a strong laboratory bias.

The standard deviations of 1.72 and 2.29 obtained for total percentage of insoluble residue are significantly lower than the precision estimate published in ASTM D3042. Based on the findings published in ASTM, the precision or multi-laboratory variation appears to vary with the level of insoluble residue. The intermediate level of insoluble residue was found to have the highest variability. In the case of percentage of insoluble residue retained 75 µm, the standard deviations 1.96 and 2.72 obtained are significantly lower than the precision estimate of 3.1 published by ASTM. The data from the MTO proficiency sample testing program may be used to evaluate the future performance of this test method.

3.4.11 LS-618 - Micro-Deval Abrasion (Coarse Aggregate) – Test No. 16

Seventy-nine laboratories reported results for this test in 2015. The test method requires reporting of control sample results to demonstrate that the testing process is in control. This year, all of the laboratories reported control sample result within the established range for the material. One outlier was rejected using the iterative technique.

The multi-laboratory coefficient of variation of 5.4% published in the LS-618 is for 19.0 mm maximum size aggregate with abrasion losses in the range from 5% to 23%. The mean loss of 8.8% in this year's program is within the range of values for which the precision estimates were established. The average coefficient of variation of 6.5% obtained in 2015 is higher than the value of 5.4% published in LS-618. It is also higher than that of the values reported in the past three years (4.3% to 5.5%). The scatter plot for this test shows combination of random variation and laboratory bias for some laboratories.

3.4.12 LS-614 - Freeze-Thaw Loss – Test No. 17

The coarse aggregate samples supplied did not contain adequate amount of material retained on the 19.0 mm sieve. For this reason, participants were advised to perform the test only on coarse aggregate passing the 19.0 mm sieve and to calculate the weighted average by assigning the same freeze-thaw loss value as the next smaller fraction, i.e., 19.0 mm - 13.2 mm for 26.5 mm to 19.0 mm that need not be tested.

Sixty laboratories reported results for this test in 2015. Participants in this test were asked to compute the percent of each fraction based on the total mass of material retained on 4.75 mm sieve. Four of the participants did not follow the

instructions, resulting in miscalculation of percent fraction. One of the participants used incorrect data from the gradation test resulting in miscalculation of the weighted average. The test method requires reporting of laboratory control sample losses to demonstrate that the testing process is in control. This information is used to alert the laboratories to testing deficiencies. Without testing of the reference material, the test is invalid (see LS-614, Section 9.1). This year, one of the laboratories reported control sample result outside the established range for the material. In addition, two outliers were identified using the iterative technique.

The multi-laboratory coefficient of variation of 21.6% published in LS-614 is for coarse aggregate with freeze-thaw losses in the range of 3% to 18%. The average mean loss of 1.73% in this test is significantly lower than the range of values (3% to 18%) for which the LS-614 precision estimate was established. The coefficient of variation of 39% obtained in 2015 is significantly higher than the value of 21.6% published in the LS-614 and the values of 22.8% to 34.7% reported in the past three years. The scatter plot for this test shows combination of random variation and laboratory bias for some laboratories.

It is likely that there are two main reasons for the spread of the data for this test: insufficient damage caused by freezing too rapidly or difference in sieving intensity. The laboratories that reported freeze-thaw losses higher than 3.1% or less than 0.38% should modify their processes to try and achieve losses closer to the mean loss of the control aggregate. Appendix 1 of LS-614 gives a procedure for determining and adjusting sieving time for quantitative analysis. Each laboratory must establish their sieving time, if the mechanical shaker and diameter of sieves are different from that were used to establish the sieving time provided in the Appendix 1 of LS-614.

3.4.13 LS-602 - Sieve Analysis (Fine Aggregate) – Test Nos. 20-25

The test samples for this procedure were prepared by the participants from the material passing the 4.75 mm sieve of the coarse aggregate gradation. This process closely follows the normal testing procedure in which the laboratory prepares its own test samples from the field sample. The scatter diagrams for the fine aggregate sieve analysis, except for percent passing 75 µm, show random variation with little laboratory bias. The scatter diagram for percent passing 75 µm shows a combination of random variation and laboratory bias for some laboratories. The standard deviations of the fine sieves in 2015 are comparable to the values reported in 2013 and 2014 and noticeably lower than the values reported in 2012. The multi-laboratory variations for 300 µm and 150 µm sieves are found to be consistent with the values published in the ASTM C 136 precision statements. In the case of 2.36 mm, 1.18 mm and 600 µm sieves, the standard deviations obtained (1.4 to 1.9) are higher than the value of 1.41 published by ASTM. For 75 µm sieve, the standard deviations obtained (0.44 and 0.51) are lower than the value of 0.65 published by ASTM.

As in previous inter-laboratory studies, it was found that the precision of the test varies as a function of the amount of material retained on any sieve. The smaller the amount of material retained, the more efficient the sieving process and the better the precision. When there is a small amount of material retained on a sieve (one layer of particles or less), the particles have a greater chance of falling through the sieve in a given time.

The number of outliers identified varies from sieve to sieve, and ranges from nine for 1.18 mm sieve to a maximum of eighteen for the 300 µm sieve. Outlier laboratories with a very low percent passing the 75 µm sieve should inspect their sieves, as low percent passing may be the result of the sieve being blinded when washing the sample. An ineffective washing process will also result in a low percent passing this sieve.

3.4.14 LS-605 - Relative Density of Fine Aggregate – Test No. 27 and Absorption of Fine Aggregate – Test No. 28

Participants in the program were asked to test the samples according to MTO Test Method LS-605. This test method follows ASTM C 128, except that it requires the removal of materials finer than 75 µm from the test specimen by washing. LS-605 requires the test specimens to be prepared in duplicate and washed on the 75 µm sieve until all of the material finer than 75 µm is removed. The presence of material finer than 75 µm in the test specimens can result in lower relative densities and higher absorption values.

In the past, MTO was using the precision estimates published in the ASTM C 128 for both relative density and absorption to compare and evaluate the multi-laboratory variations obtained from the MTO proficiency sample testing program. Considering the difference in preparation of test specimen between the ASTM C 128 and LS-604, use of the multi-laboratory variations published in the ASTM may not be appropriate to evaluate the performance of the participating laboratories. Since 2012, MTO has been using the precision estimates developed from its proficiency sample test data collected over a period of fourteen years. The latest revision of this test method provides precision estimates for both relative density and absorption of fine aggregates with absorption properties less than 2.0%.

Ninety-eight laboratories reported results for these tests in 2015. Twelve outliers for relative density (Test No. 27) and five outliers for absorption (Test No. 28) were selected using the iterative technique. As in previous years, greater variation exists in this test compared to the relative density test on coarse aggregate. It is imperative that differential drying of the various sized particles be avoided by *constant* stirring of the sample under the air current during the drying process. As short as 30-second periods of rest can be detrimental to the outcome of the test results. Differential drying of the particles is known to cause premature collapse in the cone test used to judge the saturated surface dry state.

The resulting test observations are lower relative densities and higher absorption values.

The standard deviations obtained in 2015 for both relative density (0.012 and 0.012) and absorption (0.14 and 0.14) are consistent with the values published in the LS-605 and the values reported in the past three years (refer Appendix C). As in the previous studies, the multi-laboratory variations obtained in 2015 are significantly lower than that of the values published in the ASTM C 128 precision statements. ASTM publishes a multi-laboratory variation of 0.023 and 0.23 for relative density and absorption, respectively for fine aggregates with absorption properties less than 1.0%. The scatter plots for both tests show a pronounced between laboratory bias.

3.4.15 LS-621 - Amount of Asphalt Coated Particles – Test No. 30

Two hundred and twenty-six laboratories reported results for this test in 2015. Seventeen laboratories were identified as outliers using the iterative technique. Scatter diagram provided in the Appendix D1 shows a random variation with little laboratory bias. LS-621 provides precision estimate for 19.0 mm maximum size coarse aggregate mixed with asphalt coated particles in the range of 25% to 55%. The mean values of 36.6% and 32.3% reported by the laboratories are well within the range of values for which the precision estimate was developed. The standard deviations of 2.8 and 3.7 obtained in 2015 are lower than the precision estimate of 3.9 published in the LS-621 and the values (4.9 and 5.0) reported in 2014. Laboratories that reported values of less than 28% and in excess of 40% should critically evaluate their interpretation of the definition and re-examine their samples. There is no comparable or similar ASTM test procedure.

3.4.16 LS-623 - Moisture-Density Relationship (One-Point) – Test Nos. 31-33

Participants were asked to perform this test on the material passing the 19.0 mm sieve of the Granular A samples 1.15A and 2.15A supplied. One hundred and fifty-five laboratories reported results for this test in 2015. Eight outliers for the wet density (Test No. 31) and three outliers for optimum moisture (Test No. 33) determinations were rejected using the iterative technique. The standard deviations obtained in 2015 for all three tests, i.e. wet density, dry density and optimum moisture content are in line with that of the values reported in the past three years and are lower than the precision estimates published in LS-623.

The scatter diagrams show a combination of random variation and laboratory bias for some laboratories. Possible causes for the laboratory bias may be operator error and the use of 101.6 mm diameter mould, even though the participants were requested to use only the 152.4 mm diameter mould. This test also requires significant operator skill to obtain the point within the band in the first attempt. Those laboratories with poor ratings should examine their equipment and procedure to discover the causes for this variation. There is no comparable or similar ASTM test procedure. However, ASTM D 698 covers the

laboratory compaction characteristics of soils and reports precision estimates from the tests conducted only on clayey soils.

3.4.17 LS-619 - Micro-Deval Abrasion (Fine Aggregate) – Test No. 34

Participants in this test were asked to prepare their own sample from the bags of bulk Granular A supplied. Seventy-eight laboratories reported results for this test in 2015. The test method requires reporting of control sample test results to demonstrate that the testing process is in control. This year, one of the participants reported control sample results outside the range established for the material. This laboratory was manually removed from the analyses and identified as outliers. In addition, three outliers were selected by the use of iterative technique.

LS-619 provides precision estimates for fine aggregates with the abrasion loss in the range of 7% to 18%. The coefficient of variation of 9.2% obtained in 2015 is higher than the precision estimate of 7.6% published in LS-619 and the values (6.2% to 7.8%) reported in the past three years. However, the majority of the data points are located in the lower left and upper right quadrant of the scatter diagram indicating a strong laboratory bias.

3.4.18 LS-620 - Accelerated Mortar Bar – Test No. 123

Unlike other aggregate tests, the accelerated mortar bar test is not included in the Aggregate and Soil Proficiency Sample Testing Program each year. This test was conducted in the 2004 and 2010 MTO Proficiency Sample Testing Programs. The data from 2015 program will be used to update the participants list. The participants in this test were supplied with fine aggregate samples 1.15M and 2.15M. Twenty-four laboratories reported their test results in 2015. The participants were asked to test three mortar bars made with each of the aggregate samples supplied. The use of standard cement to improve the multi-laboratory precision was found to be not worthwhile (Rogers, 1999). With this in view, standard cement was not specified for the 2015 study and the participants used their own cement.

The participants reported expansion of the individual bars and the average of three bars after 1, 3, 7, 13, 14 days. Only the average expansion after 14 days was analysed and shown on the scatter diagram in the Appendix D1. Iterative technique was employed to reject two outliers from the data set. The scatter diagram indicates a strong laboratory bias. The mean expansion at 14 days obtained from this study is 0.173% and 0.179%. The standard deviations obtained are 0.030 and 0.036, respectively.

In the 2004 and 2010 MTO proficiency Sample Testing Programs, the participants were asked to perform the test on fine aggregate (Sample 1) and Spratt control coarse aggregate (Sample 2). 2010 was the only year when the participants were required to perform the test using the standard cement supplied

by MTO. For this reason, comparison of the multi-laboratory variations between previous test periods is made based on expansion of the fine aggregate samples only.

The standard deviations obtained in 2015 study are slightly higher than that of the value (0.028 for fine aggregate with a mean value of 0.191) found in the 2010 study but slightly lower than that of the value (0.035 for fine aggregate with a mean value of 0.196) found in the 2004 study. The average coefficient of variation found in 2015 (18.7%) is higher than that of the values (17.9% and 14.1%) reported in 2004 and 2010 for fine aggregate, and the precision statement (15.2%) published by ASTM C1260. Several steps in the test procedure can influence the results, particularly maintaining the temperature of storing the specimens, procedure of molding the specimens, calibration of equipment and measuring procedure, variations of standard cement and sodium hydroxide that were used in the test. Laboratories shall carefully examine their equipment and procedure.

3.4.19 LS-702 - Particle Size Analysis of Soil – Test Nos. 40-45

Participants in this test were instructed to submit the data sheets to demonstrate that the test was done according to LS-702. Eighty-five laboratories participated in the hydrometer test in 2015. Ninety percent of the laboratories reported results ranging from 99.8% to 100% of material passing the 2.00 mm sieve. For this reason, the data for 2.0 mm sieve (Test No. 40) was also subjected to the statistical analysis using no outlier technique. This technique does not assign rating for individual test. As a result, no rating was assigned for 2.0 mm sieve and the results of the analysis are reported for information purpose only.

Outliers were selected using the iterative technique. The number of outliers identified by the use of iterative technique range from two for percent passing 20 µm, 5 µm and 2 µm to a maximum of five for percent passing 425 µm. Successive scatter diagrams for this test show pronounced between laboratory biases for percent passing 20 µm, 5 µm and 2 µm. Scatter diagrams for percent passing 425 µm and 75 µm show random variation with little laboratory bias. The standard deviations obtained in 2015 for all the particle sizes passing, except 2.0mm, 75 µm and 20 µm, are consistent with that of the values reported in 2014. The standard deviations obtained for the 2.0 mm, 75 µm and 20 µm sizes are slightly higher than the variations reported in 2014. The laboratories that are identified as outliers should examine their equipment and technician's skills to ensure that they meet the requirements of the test procedure.

3.4.20 LS-703 and 704 - Atterberg Limits of Soil – Test Nos. 46-48

One hundred and two laboratories reported results for Atterberg limit tests in 2015. Five outliers for liquid limit (Test No. 46) and three for plastic limit test (Test No. 47) were identified using the iterative technique. The scatter plots for both liquid and plastic limit tests as well as for plasticity index (Test No. 48) show

strong laboratory bias. Both liquid and plastic limit tests require significant operator skills. Liquid limit test also requires good condition and calibration of the apparatus. Close attention to the condition and calibration of the liquid limit apparatus and employing skilled technicians may reduce the laboratory biases.

The material supplied for the soil tests in 2015 is a medium to high plastic clay (CI to CH) with liquid limit in the neighbourhood of 50 (LL = 50±). In view of this, the multi-laboratory variations (1s) published in the ASTM for high plastic clay (CH) with a liquid limit of 59.9 and plastic limit of 20.4 are used to evaluate the performance of the participants in the 2015 program. The standard deviations obtained for plastic limit and plasticity index are significantly lower than the values published in the ASTM precision statements (refer Appendix C). For liquid limit test, standard deviations obtained are consistent with that of the precision estimate published in ASTM D 4318. The variations obtained for all three index tests in 2015 are consistent with that of the values reported in 2014, but slightly higher than that of the values reported in 2013.

3.4.21 LS-705 - Specific Gravity of Soils – Test No. 49

The participants were requested to perform this test according to LS-705. This test method requires that the test be performed on a minimum of three specimens, and the range (difference between the largest and smallest) of specific gravity values of the test specimens determined is within 0.02. Further, it requires that the test be repeated if the range exceeds the specified limit. The laboratories that reported results with the range in excess of 0.02 appear to have difficulty in repeating the test within their testing environment. In 2015, eight laboratories reported specific gravity values with the range in excess of the specified limit of 0.02. These eight laboratories were manually removed from the statistical analysis and identified as outliers.

Eighty-five laboratories reported results for this test in 2015. In addition to the laboratories that were removed manually, five more outliers were identified using the iterative technique. The majority of the data points are located in the first and third quadrants of the scatter diagram showing a pronounced between laboratory bias. Several steps in this test procedure can influence the results, particularly the equipment and method employed for preparation of the test specimen and removal of entrapped air from the test specimen. Laboratories finding themselves in this situation should carefully examine their equipment and procedure.

The standard deviation of 0.026 obtained in 2015 is slightly lower than the results reported in 2014 but slightly higher than the results (0.023 to 0.025) reported in the 2012 and 2013 studies. LS-705 is similar to that of AASHTO T 100, which reports a multi-laboratory standard deviation of 0.04. As in the past three studies, the standard deviations obtained in 2015 are also found to be significantly lower than that of the precision estimate published in the AASHTO T 100.

3.5 SUPERPAVE CONSENSUS PROPERTY TESTS

3.5.1 LS-629 - Uncompacted Void Content of Fine Aggregate – Test No. 95

The participants were asked to perform the test in accordance with LS-629, using the fine aggregate prepared by splitting the material passing 4.75 mm sieve of the Granular A. This test method is a modified version of AASHTO T 304. LS-629 follows Method A of AASHTO T 304, except for the preparation of the test specimen to be used in the determination of bulk specific gravity of fine aggregates. The significant difference between the methods is that LS-629 requires the test specimens be washed on the 75 µm sieve until all the material finer than 75 µm is removed. In addition, LS-629 specifies that the bulk relative density is determined using the graded sample and not the individual size fraction method described in Clause 9.4 of AASHTO T 304. In order to minimise the testing work, the participants were advised to use the bulk relative densities reported for fine aggregate determined in accordance with LS-605 under Test No. 27, to compute the uncompacted void contents of samples 3.15 and 4.15.

Sixty-four laboratories submitted results for this test in 2015. Eight laboratories were identified as outliers using the iterative technique. Over 75% of the points on the scatter diagram are accounted in the first and third quadrant, indicating a strong laboratory bias. The standard deviations of 0.52 and 0.49 obtained in 2015 show improvement over the values obtained in the past three years. The standard deviations obtained for both samples are significantly higher than the value of 0.33% published in AASHTO T 304 precision statements for graded standard sand. The estimates of precision published in AASHTO T 304 are based on graded sand as described in ASTM C 778, which is considered rounded, and is graded from 600 µm to 150 µm. The type of material used for the development of precision statements in AASHTO T 304 may not be typical of the sand samples that were used in this testing program. The uncompacted void contents reported were calculated using the bulk relative densities that were determined by the individual laboratories. The use of the bulk relative densities determined by the individual laboratories further compounds the variations associated with the results reported for uncompacted void contents. The laboratories that are identified as outliers should review their test procedures and the skill of the technician.

3.5.2 ASTM D 2419 - Sand Equivalent Value of Fine Aggregate - Test No. 96

Participants were asked to prepare the fine aggregate sample for this test by splitting the Granular A material passing 4.75 mm sieve. Two alternate procedures for the preparation of test specimen (air-dry or pre-wet) are allowed in both ASTM and AASHTO methods. The participants were given the option of preparing the test specimen in accordance with either method.

Sixty-two laboratories reported results for this test in 2015. No outlier was identified by the use of critical value method or iterative technique. The lower left and upper right quadrants of the scatter diagram account for over 90% of the

points showing pronounced laboratory bias. The standard deviations of 8.6 and 8.7 obtained in 2015 are significantly higher than the values reported in the 2014 study and slightly higher than the multi-laboratory precision estimate of 8.0 published by ASTM for samples with sand equivalent value less than 80. The standard deviations obtained in 2015 are consistent with the values reported in 2013.

3.5.3 ASTM D 5821 - Percent of Fractured Particles – Test No. 97

The Granular A samples 1.15A and 2.15A supplied did not contain adequate amount of material retained on 19.0 mm sieve. For this reason, the participants were advised to perform the test only on coarse aggregate passing the 19.0 mm sieve.

ASTM D 5821 is very similar to MTO LS-607. Seventy laboratories submitted results for this test in 2015. Seven outliers were detected using the iterative technique. The scatter diagram shows a strong laboratory bias. The average means determined by the ASTM method (66.8%) and MTO version (64.9%) on the same aggregate samples differs only by 2.0%, which is significantly lower than the multi-laboratory variations published by ASTM (5.2%) and MTO LS-608 (4.7%). Further, the standard deviations (4.7 and 4.3) obtained in 2015 are significantly lower than the precision estimate of 5.2 published by ASTM. ASTM has not conducted inter-laboratory studies to determine a precision estimate and currently publishes statistical data provided by MTO. The variation obtained in 2015 is noticeably higher than that of the values reported in 2014, but consistent with that of the values (4.6 and 4.3) reported in 2013.

3.5.4 ASTM D 4791 - Percent Flat and Elongated Particles – Test No. 99

The coarse aggregate samples supplied did not contain adequate amount of material retained on the 19.0 mm sieve. For this reason, participants were advised to perform the test only on coarse aggregate passing the 19.0 mm sieve, using a ratio of 5:1 and to calculate the weighted average by assigning the same percent flat and elongated particles value as the next smaller fraction, i.e., 19.0 mm - 13.2 mm, for 26.5 mm to 19.0 mm that need not be tested.

Seventy laboratories reported results for this test in 2015. Participants in this test were asked to compute the percent of each fraction using the gradation test results of the coarse aggregate portion, based on the total mass of material retained on 4.75 mm sieve. And all five fractions shall be used in calculation of the weighted average of percent flat and elongated particles. Six of the participants did not follow the instructions, resulting in miscalculation of percent fraction. One of the participants did not use all five fractions in the calculation. Two of the participants used incorrect data from the gradation test resulting in miscalculation of the weighted average. In addition, three outliers were detected using the iterative technique. The standard deviations of 0.42 and 0.43 obtained in 2015 are significantly lower than the values (0.61 to 0.80) reported in 2013 and

2014. The average coefficient of variation of 55.2% obtained in 2015 shows improvement over the values (55.2% to 64.5%) obtained in the past 3 years. The scatter plot for this test shows combination of random variation and laboratory bias for some laboratories.

ASTM D 4791 requires that the percent flat and elongated particles results are reported separately for each fraction tested. The precision estimates in this test method are also provided separately for each fraction ranging from 19.0 mm to 12.5 mm, 12.5 mm to 9.5 mm, and 9.5 mm to 4.75 mm. However, the results reported in this study are based on the weighted average calculated using the results of five fractions ranging from 26.5 mm to 4.75.mm. For this reason, a direct comparison of the multi-laboratory variations obtained in this study with that of the precision estimates published by ASTM is not possible.

4. Laboratory Rating System

The laboratory rating system assigns separate overall ratings for each category of laboratories, i.e., low complexity (Production) aggregate laboratories, high complexity (Full Service) Aggregate laboratories, Soil laboratories, and Superpave laboratories. Laboratories must participate in all of the tests that are listed under each category, i.e., Production, Full Service, Soil and Superpave, to assign an overall laboratory rating. Production (CCIL Type C) laboratories are required to carry out wash pass 75 μm, sieve analysis, percent crushed particles, percent asphalt coated particles, and percent flat and elongated particles tests. In addition to these tests, Full Service laboratories (CCIL Type D) must carry out micro-Deval (coarse and fine), freeze-thaw, and/or magnesium sulphate soundness, relative density and absorption (coarse and fine) tests. Soil laboratories are required to carry out particle size analysis, Atterberg limits, and specific gravity of soil tests. Superpave aggregate laboratories are required to perform all four consensus property tests, i.e., uncompacted void content, sand equivalent value, percent fractured particles, and flat and elongated particles.

The rating system gives a maximum rating of 10 for each test, e.g., 5 for wash pass 75 μm on sample 1.15, plus -5 for wash pass 75 μm on sample 2.15, equals 10 (the negative sign indicating a test result less than the mean is ignored). See Section 2.1 for explanation of test method ratings. Some tests that are normally reported together are averaged and given a maximum of 10. The relative density and absorption (coarse and fine), one-point Proctor values (maximum wet and dry density, and optimum moisture content), particle size analysis of soils, and Atterberg limits are treated in this manner. Because of the large number of individual test ratings in the sieve analysis results, the ratings are modified so as not to unduly bias the overall balance between various tests. The ratings for each sieve size are added and then divided by eleven coarse and fine sieves for which results were reported, and multiplied by 3 to give a laboratory rating with a maximum of 30 for this test. Individual laboratory ratings are calculated by adding the ratings of each test in the appropriate lab category (i.e. Production, Full Service, Soil, or Superpave) and converting the sum to a percentage of the maximum available rating for the category. The spread of laboratory ratings for Production, Full Service, Soil, and Superpave laboratories are given in the form of histograms in Figures 2 to 5. The rating system for "Full Service Laboratory" (Type D) shows that 48% of the participating laboratories in 2015 obtained a rating higher than 90 and, in the case of "Production Laboratory" (Type C), 40% of the participants obtained an overall laboratory rating higher than 90. The rating system for soil tests show 53% of the participants obtained an overall rating higher than 90, and in the case of consensus property tests (Superpave), 44% of the participants obtained an overall laboratory rating higher than 90. The laboratory rating system data is reported in the Appendices F1, F2, F3, and F4.

5. Conclusions

The method of proficiency sample preparation employed by MTO resulted in almost identical mean gradation values for samples 1.15 and 2.15. The differences in mean, as well as in the standard deviations between pairs of samples for both coarse and fine sieves are almost negligible. Based on the results, it may be concluded that the sample preparation method employed is very effective and capable of producing a uniform and nearly identical material at reasonable cost.

The majority of the aggregate and soil test results of the 2015 Aggregate and Soil Proficiency Sample Testing Program compare favourably with the results of previous studies. In some cases, the variations show noticeable improvement over previous years' results and the precision estimates of those tests where ASTM, AASHTO or MTO precision statements are available. The scatter diagrams for the majority of the aggregate tests show either random variation or a combination of random variation and laboratory bias for some laboratories.

Two hundred and twenty-six of the laboratories that participated in the aggregate tests are CCIL Type C (Production) certified, and sixty of those are also CCIL Type D (Full Service) certified. CCIL inspects the certified laboratories for quality control procedures, ability of technicians, and condition and calibration of the equipment at about two year intervals. The performance of laboratories in most of the aggregate tests (Type C and Type D) is consistent with the results in the past and a large number of these tests show improvement in multi-laboratory variation over the established precision estimates. The improvements noted may be due to the on-site laboratory inspection by CCIL at regular intervals, proficiency sample testing, and due to an increased awareness of the importance of proper testing and quality control procedures implemented by CCIL.

Eighty-four laboratories participated in all three soil tests. The variations found in 2015 for the soil tests are consistent with that of the values reported in the last three years' studies, but the scatter diagrams of all three tests still show strong laboratory biases. The results of soil tests are significantly influenced by operator skills, testing environment, and the condition and calibration of the equipment.

Sixty-one laboratories participated in all four Superpave consensus property tests. The results of 2015 compare favourably with the results of past three years. The multi-laboratory variations of uncompacted void content (LS-629) and percent flat and elongated particles of coarse aggregate (D 4791) tests show noticeable improvements over the values reported in the past two years. The multi-laboratory variations of percent flat and elongated (D 4791) and percent fractured particles of coarse aggregate (D 5821) tests show noticeable improvements over the precision estimates published by ASTM. As in the past, the scatter diagrams for LS-629, ASTM D 2419 and D 5821 show strong

laboratory biases. The quality control program implemented by CCIL is expected to bring about improvements in the multi-laboratory variations.

6. Recommendations

Although there are improvements in the multi-laboratory variations over the precision estimates established by ASTM and MTO, strong laboratory biases still remain in a few of the aggregate tests, three of the Superpave property test procedures and all of the soil tests. The laboratories that were identified as outliers need to examine their quality control practices, the condition and calibration of equipment, testing procedures and skills of their technicians. Laboratories that receive a rating of 2 or less for an individual sample in a test should investigate the probable cause and prepare corrective action reports as required by the Quality System implemented by CCIL.

The results of the 2015 MTO Aggregate and Soil Proficiency Sample Testing Program suggest that most laboratories have performed satisfactorily. Laboratories that obtained relatively low ratings must focus on quality control practices, operator training, standardization and calibration of equipment and improvements to laboratory environments in order to improve their performance.

For all of the tests that were included in this study, the equipment to be used is regulated by the test method itself. A good state of equipment maintenance, repair and correct calibration is required in order to achieve improvements. It is expected that the CCIL Quality System will encourage laboratories to conduct a review of their internal quality control practices to ensure that they have the correct equipment and properly trained technicians. Laboratories will find that a well-documented and regular program of internal inspection, calibration and testing of control or reference samples is beneficial to maintaining a high level of confidence in their results.

7. Acknowledgments

The authors would like to acknowledge Henry Bykerk, Bob Gorman and Carole Anne MacDonald of the Soils and Aggregates Section for the selection of aggregate materials for the 2015 proficiency sample testing program. We would also like to thank the many laboratory staff, students and engineers-in-training of the Materials Engineering and Research Office for their dedicated assistance in preparing more than 2520 individual samples, from approximately 50 tonnes of aggregate and soil material, for distribution to the program participants.

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Appendix A: Glossary of Terms

Acceptable difference between two results (difference two-sigma limit (d2s)) as an index of precision is the maximum acceptable difference between two results obtained on test portions of the same material tested by two different laboratories. The index, d2s, is the difference between two individual test results that would be equalled or exceeded in only one case in twenty in the normal and correct operation of the method. The index is calculated by multiplying the multi-laboratory standard deviation (1s) by the factor $2\sqrt{2}$ (2.83).

Accuracy refers to the degree of mutual agreement between a set of measurements with an accepted reference or 'true value'. This 'true' or reference value can be an assigned value arrived at by actual experiments.

Bias of a measurement process is a consistent and systematic difference between a set of test results derived from using the process and an accepted reference value of the property being measured. For the majority of aggregate and soil tests, there is no acceptable reference material, so bias is impossible to compute.

Coefficient of Variation expresses the standard deviation as a percentage of the mean, where:

$$C.V. = \frac{\text{std dev}}{\text{mean}} \times 100$$

Critical Value is that value of the sample criterion which would be exceeded by chance with some specified probability (significance level) on the assumption that all the observations did indeed constitute a random sample from a common system of causes.

MAIDB refers to Mineral Aggregate Inventory Data Bank of the Ministry of Transportation.

Median is synonymous with the middle and the **sample median** is the middle value of a list of test results when the observations are ordered from smallest to largest in magnitude. After rearranging the observations in increasing order (from most negative to most positive), the **sample median** is the *single middle value* in the ordered list, if n is odd, or the *average of the two middle values* in the ordered list, if n is even, where n equals the number of observations.

Multi-laboratory precision is a quantitative estimate of the variability of a large group of individual test results when each test has been made in a different laboratory and every effort has been made to make test portions of the material as nearly identical as possible. Under normal circumstances, the estimates of the one-sigma limit (1s) for multi-laboratory precision are usually larger than those for single-operator precision because different operators and different equipment are being used in different laboratories.

Outlier is a measurement that, for a specific degree of confidence, is not part of the population. In this study, an outlier is generally three or more standard deviations from the mean, giving a confidence level of ninety-nine percent. If a laboratory test result is classified as an outlier, it means that something went wrong either with the sample or in the laboratory.

Precision refers to the degree of mutual agreement between individual measurements on the same material. In other words, precision is a measure of how well the individual test results of a series agree with each other.

Sample mean or average is the sum of all observations divided by the total number of observations.

Single operator precision (one-sigma limit (1s)) indicates the variability, as measured by the deviations above and below the average, of a large group of individual test results when the tests have been made on the same material by a single operator using the same apparatus in the same laboratory over a relatively short time.

Standard deviation is the most usual measure of the dispersion of observed values or results expressed as the positive square root of the variance.

Variance is a measure of the squared dispersion of observed values or measurements expressed as a function of the sum of the squared deviations from the population mean or sample average.

Appendix B1: List of Participants

2015 Participants List Ministry of Transportation Aggregate and Soil Proficiency Sample Testing Program For further information on this program, contact: Zhiyong Jiang (416) 235-4901, or Stephen Senior (416) 235-3734	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
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	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
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2015 Participants List

Ministry of Transportation
Aggregate and Soil
Proficiency Sample
Testing Program

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Stephen Senior (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
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	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
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Ministry of Transportation

Aggregate and Soil Proficiency Sample Testing Program

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Stephen Senior (416) 235-3734

	LS-601 Wash Pass 75µm	LS-602 Sieve Analysis	LS-603 Los Angeles Abrasion	LS-604/5 Relative Density	LS-606 Sulphate Soundness	LS-607 Percent Crushed Particles	LS-608 Percent Flat and Elongated	LS-609 Petrographic Number - Concrete	LS-616 Petrographic Analysis – Fine	LS-614 Freeze-Thaw	LS-613 Insoluble Residue	LS-618 Micro-Deval CA	LS-619 Micro-Deval FA	LS-620 Accelerated Mortar Bar	LS-621 Asphalt Coated Particles	LS- 623 One Point Proctor Density	LS-702 Particle Size Analysis	LS-703/4 Atterberg Limits	LS-705 Specific Gravity of Soils
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2015 Participants List
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2015 Participants List

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Appendix B2: List of Participants

2015 Participants List Ministry of Transportation Superpave Aggregate Consensus Property Testing Program For further information on this program, contact: Zhiyong Jiang (416) 235-4901 or Stephen Senior (416) 235-3734		LS-629 - Uncompacted Void Content of Fine Aggregate (AASHTO T 304)	ASTM D 2419/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
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2015 Participants List

Ministry of Transportation

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	LS-629 - Uncompacted Void Content of Fine Aggregate (AASHTO T 304)	ASTM D 2419/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
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2015 Participants List

Ministry of Transportation

Superpave Aggregate Consensus Property Testing Program

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		LS-629 - Uncompacted Void Content of Fine Aggregate (AASHTO T 304)	ASTM D 2419/AASHTO T 176 – Sand Equivalent Value of Fine Aggregate	ASTM D 5821 – Percent of Fractured Particles in Coarse Aggregate	ASTM D 4791 – Percent Flat Particles, Elongated Particles or Flat & Elongated Particles in Coarse Aggregate
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Appendix C: Multi-Laboratory Precision

Test 1	2012		2013		2014		2015		MTO LS-601
WP 75 μm	1.12	1.12	1.13	2.13	1.14	2.14	1.15	2.15	
Mean	2.39	2.26	1.22	1.22	1.00	1.15	1.84	1.84	< 2.5
1S	0.31	0.32	0.28	0.25	0.16	0.18	0.25	0.25	0.20
D2S	0.86	0.90	0.79	0.72	0.45	0.51	0.71	0.70	0.58
n/Outliers	199/18		201/21		205/21		207/19		

Test 2	2012		2013		2014		2015		ASTM C136[A]
P 19.0 mm	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	
Mean	95.0	93.7	95.8	95.8	96.7	96.9	98.1	97.9	100 - 95
1S	1.0	1.1	0.8	0.8	0.7	0.6	0.5	0.6	0.35
D2S	2.8	3.1	2.4	2.4	1.9	1.7	1.3	1.6	1.0
n/Outliers	215/2		213/10		220/6		222/4		

Test 3	2012		2013		2014		2015		ASTM C136[A]
P 16.0 mm	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	
Mean	90.2	87.6	90.0	89.9	88.6	89.2	90.9	90.0	95 - 85
1S	1.6	1.6	1.1	1.2	1.1	1.0	0.9	1.2	1.37
D2S	4.6	4.6	3.1	3.5	3.0	2.9	2.6	3.4	3.9
n/Outliers	211/5		207/15		221/5		218/8		

Test 4	2012		2013		2014		2015		ASTM C136[A]
P 13.2 mm	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	
Mean	85.4	82.0	83.7	83.6	79.5	80.6	82.4	80.9	85 - 80
1S	1.9	1.8	1.5	1.5	1.3	1.4	1.2	1.4	1.92
D2S	5.5	5.2	4.3	4.3	3.7	4.1	3.3	4.0	5.4
n/Outliers	209/8		209/14		219/7		218/8		

Test 5	2012		2013		2014		2015		ASTM C136[A]
P 9.5 mm	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	
Mean	75.8	71.5	72.1	71.8	63.4	65.1	68.8	66.8	80 – 60
1S	2.3	2.2	1.6	1.7	1.3	1.7	1.0	1.7	2.82
D2S	6.4	6.4	4.5	4.8	3.8	4.7	2.9	4.7	8.0
n/Outliers	210/7		201/22		214/12		214/12		

Test 6	2012		2013		2014		2015		ASTM C136[A]
P 4.75 mm	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	
Mean	58.1	53.8	54.8	54.2	45.3	46.9	52.2	50.4	60 – 20
1S	2.3	2.2	1.5	1.7	1.3	1.5	1.1	1.5	1.97
D2S	6.6	6.2	4.3	4.9	3.6	4.3	3.0	4.2	5.6
n/Outliers	207/10		204/19		214/12		210/16		

Test 8	2012		2013		2014		2015		ASTM C131	
L. A	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	C of V	σ^*
Mean	22.6	21.9	22.2	22.1	26.4	26.5	25.0	25.1	10-45	25.0
1S	1.32	1.34	1.2	0.9	1.3	1.1	1.4	0.8	4.5%	1.1
D2S	3.73	3.81	3.3	2.5	3.7	3.2	3.9	2.2	12.7%	3.1
n/Outliers	11/0		9/1		11/0		10/0			

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 9	2012		2013		2014		2015		MTO LS-604
RD (O.D.)	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	
Mean	2.655	2.657	2.625	2.624	2.666	2.665	2.688	2.688	
1S	0.008	0.008	0.006	0.006	0.007	0.006	0.007	0.006	0.006
D2S	0.023	0.023	0.017	0.017	0.020	0.017	0.020	0.017	0.016
n/Outliers	102/3		98/6		93/6		93/6		

Test 10	2012		2013		2014		2015		MTO LS-604
ABS	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	
Mean	2.094	2.063	1.133	1.126	0.734	0.740	1.188	1.186	< 2%
1S	0.121	0.134	0.076	0.072	0.078	0.079	0.066	0.067	0.09
D2S	0.342	0.379	0.215	0.204	0.220	0.223	0.187	0.190	0.25
n/Outliers	102/3		101/3		94/5		92/7		

Test 11	2012		2013		2014		2015		ASTM C88	
$MgSO_4$	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	C of V	σ^*
Mean	26.1	25.3	3.7	3.5	4.8	4.7	2.3	2.4	9-20%	2.3
1S	5.4	5.3	1.8	1.9	1.4	1.0	0.8	1.1	25%	0.6
D2S	15.2	15.0	5.0	5.3	4.1	2.8	2.2	3.0	71%	1.7
n/Outliers	42/1		44/0		39/4		40/2			

Test 12	2012		2013		2014		2015		MTO LS-607
% Crush	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	
Mean	76.9	77.5	69.1	69.3	76.4	76.4	64.6	65.2	55% - 85%
1S	5.6	5.9	3.8	3.7	3.2	3.3	4.2	4.1	4.7
D2S	15.8	16.7	10.8	10.6	9.1	9.5	11.8	11.5	13.2
n/Outliers	201/15		208/14		208/18		176/50		

Test 13	2012		2013		2014		2015		MTO LS-608
% F & E	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	
Mean	3.7	3.6	6.9	6.7	4.9	4.5	3.5	3.3	2.0% - 9.5%
1S	1.8	1.9	2.5	2.4	1.8	1.7	1.2	1.3	2.3
D2S	5.1	5.3	7.2	6.7	5.1	5.0	3.4	3.5	6.4
n/Outliers	203/11		215/6		216/10		180/46		

Test 14	2012		2013		2014		2015		MTO LS-609
PN Conc.	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	
Mean	131.4	127.7	-	-	112.8	112.0			No Precision Statements for this Test.
1S	15.4	10.0	-	-	5.3	5.4			
D2S	43.3	24.7	-	-	14.9	15.4			
n/Outliers	28/8		35		28/5				

Test 16	2012		2013		2014		2015		MTO LS-618	
MDA, CA	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	C of V	σ
Mean	19.2	19.1	11.5	11.5	11.8	11.9	8.8	8.8	5-23%	8.8
1S	1.14	0.92	0.45	0.54	0.64	0.69	0.52	0.63	5.4%	0.48
D2S	3.23	2.59	1.27	1.52	1.82	1.95	1.47	1.79	15.2%	1.34
n/Outliers	72/5		76/4		75/3		78/1			

Test 17	2012		2013		2014		2015		MTO LS-614	
Freeze-thaw	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	C of V	σ
Mean	10.11	9.77	3.30	3.16	8.71	8.64	1.74	1.72	3-18%	1.73
1S	2.82	3.00	1.10	1.13	2.08	1.87	0.68	0.67	21.6%	0.37
D2S	8.00	8.51	3.10	3.19	5.89	5.29	1.92	1.90	61.0%	1.06
n/Outliers	58/1		60/2		58/3		52/8			

A – AMRL reports percent passing inch series equivalent sieves.

σ^* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 20	2012		2013		2014		2015		ASTM C136[A]
P 2.36 mm	3.12	4.12	3.13	4.13	3.14	4.14	3.15	4.15	
Mean	43.2	40.3	44.9	44.5	35.3	36.6	42.4	40.1	60 - 20
1S	2.5	2.3	1.9	1.8	1.5	1.8	1.4	1.8	1.41
D2S	7.0	6.4	5.5	5.0	4.2	5.1	3.9	5.2	4.0
n/Outliers	203/14		207/16		212/14		215/11		

Test 21	2012		2013		2014		2015		ASTM C136[A]
P 1.18 mm	3.12	4.12	3.13	4.13	3.14	4.14	3.15	4.15	
Mean	30.2	28.5	37.6	37.3	26.6	27.7	34.0	33.1	60 - 20
1S	2.2	2.1	1.9	1.7	1.6	1.8	1.6	1.9	1.41
D2S	6.2	5.9	5.5	4.9	4.4	5.1	4.5	5.5	4.0
n/Outliers	205/12		209/14		214/12		217/9		

Test 22	2012		2013		2014		2015		ASTM C136[A]
P 600 µm	3.12	4.12	3.13	4.13	3.14	4.14	3.15	4.15	
Mean	22.0	21.0	27.4	27.4	17.9	18.6	25.6	25.1	60 - 20
1S	1.6	1.7	1.5	1.5	1.2	1.4	1.4	1.7	1.41
D2S	4.5	4.9	4.3	4.3	3.5	4.1	3.9	4.9	4.0
n/Outliers	201/16		203/20		214/12		214/12		

Test 23	2012		2013		2014		2015		ASTM C136[A]
P 300 µm	3.12	4.12	3.13	4.13	3.14	4.14	3.15	4.15	
Mean	16.5	16.0	14.1	14.1	10.2	10.5	16.8	16.7	20 – 15
1S	1.2	1.2	0.84	0.85	0.8	0.9	0.9	1.2	1.10
D2S	3.5	3.4	2.4	2.4	2.2	2.6	2.5	3.5	3.1
n/Outliers	199/18		203/20		214/12		208/18		

Test 24	2012		2013		2014		2015		ASTM C136[A]
P 150 µm	3.12	4.12	3.13	4.13	3.14	4.14	3.15	4.15	
Mean	12.3	12.0	10.3	10.3	6.2	6.3	11.1	11.1	15 - 10
1S	0.8	0.8	0.6	0.6	0.5	0.5	0.6	0.8	0.73
D2S	2.3	2.3	1.8	1.8	1.4	1.3	1.8	2.4	2.1
n/Outliers	198/19		210/13		206/20		210/16		

Test 25	2012		2013		2014		2015		ASTM C136[A]
P 75 µm	3.12	4.12	3.13	4.13	3.14	4.14	3.15	4.15	
Mean	9.1	8.8	8.7	8.7	4.4	4.4	6.7	6.8	10 - 2
1S	0.6	0.6	0.5	0.5	0.3	0.4	0.4	0.5	0.65
D2S	1.7	1.7	1.5	1.5	1.0	1.1	1.2	1.4	1.8
n/Outliers	200/17		214/9		213/12		213/13		

Test 27	2012		2013		2014		2015		MTO LS-605
RD (O.D.)	3.12	4.12	3.13	4.13	3.14	4.14	3.15	4.15	
Mean	2.647	2.649	2.650	2.650	2.666	2.665	2.711	2.712	
1S	0.011	0.009	0.013	0.013	0.009	0.011	0.012	0.012	0.012
D2S	0.031	0.025	0.037	0.037	0.025	0.031	0.034	0.034	0.034
n/Outliers	95/10		99/4		90/8		86/12		

Test 28	2012		2013		2014		2015		MTO LS-605
ABS	3.12	4.12	3.13	4.13	3.14	4.14	3.15	4.15	
Mean	1.171	1.148	1.351	1.329	0.709	0.719	1.129	1.105	< 2.0%
1S	0.15	0.16	0.16	0.12	0.12	0.13	0.14	0.14	0.16
D2S	0.44	0.46	0.44	0.34	0.34	0.36	0.39	0.38	0.44
n/Outliers	96/9		93/10		92/6		93/5		

A – AMRL reports percent passing inch series equivalent sieves.

σ* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 30	2012		2013		2014		2015		MTO LS-621
% ACP	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	
Mean	47.1	47.6	54.4	54.8	45.7	39.4	36.6	32.3	25% - 55%
1S	5.4	5.2	2.9	3.0	5.0	4.9	2.8	3.7	3.9
D2S	15.2	14.8	8.1	8.4	14.3	13.7	7.9	10.3	11.1
n/Outliers	205/11		202/20		211/14		209/17		

Test 31	2012		2013		2014		2015		MTO LS-623
MWD	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	
Mean	2.416	2.421	2.422	2.425	2.365	2.367	2.431	2.435	
1S	0.032	0.032	0.024	0.024	0.029	0.027	0.024	0.027	0.030
D2S	0.090	0.090	0.070	0.070	0.082	0.076	0.068	0.076	0.084
n/Outliers	133/14		141/14		144/12		147/8		

Test 32	2012		2013		2014		2015		MTO LS-623
MDD	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	
Mean	2.257	2.264	2.265	2.267	2.200	2.204	2.273	2.278	
1S	0.035	0.034	0.025	0.027	0.030	0.026	0.028	0.032	0.032
D2S	0.099	0.096	0.071	0.076	0.085	0.073	0.079	0.091	0.091
n/Outliers	140/7		144/11		147/9		151/4		

Test 33	2012		2013		2014		2015		MTO LS-623
OMC	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	
Mean	7.13	7.07	7.05	7.02	7.57	7.55	7.00	6.94	
1S	0.33	0.33	0.26	0.26	0.23	0.26	0.27	0.30	0.36
D2S	0.93	0.92	0.74	0.74	0.66	0.72	0.77	0.83	1.02
n/Outliers	144/3		146/9		145/11		152/3		

Test 34	2012		2013		2014		2015		MTO LS-619	
MDA, FA3	3.12	4.12	3.13	4.13	3.14	4.14	3.15	4.15	C of V	σ
Mean	17.6	17.7	15.6	15.7	10.3	10.4	15.9	15.7	7-18%	15.8
1S	1.1	1.1	1.2	1.2	0.8	0.9	1.3	1.6	7.6%	1.2
D2S	3.0	3.0	3.4	3.4	2.2	2.5	3.7	4.5	21.4%	3.4
n/Outliers	71/6		79/1		73/5		74/4			

Test 40	2012		2013		2014		2015		MTO LS-702
P 2.0 mm	5.12	6.12	5.13	6.13	5.14	6.14	5.15	6.15	
Mean	100	100	99.6	99.8	99.9	99.8	99.9	99.9	No MTO
1S			0.3	0.2	0.1	0.1	0.2	0.2	precision
D2S			0.9	0.5	0.3	0.3	0.6	0.7	statements for
n/Outliers	76/0		90/0		88/0		85/0		this test

Test 41	2012		2013		2014		2015		MTO LS-702
P 425 µm	5.12	6.12	5.13	6.13	5.14	6.14	5.15	6.15	
Mean	99.8	99.8	96.7	97.0	97.6	97.6	97.4	97.6	No MTO
1S	0.2	0.2	0.7	0.5	0.3	0.3	0.4	0.3	precision
D2S	0.5	0.5	1.9	1.5	1.0	1.0	1.0	0.9	statements for
n/Outliers	71/5		86/4		80/8		80/5		this test

Test 42	2012		2013		2014		2015		MTO LS-702
P 75 µm	5.12	6.12	5.13	6.13	5.14	6.14	5.15	6.15	
Mean	99.1	99.1	91.3	91.7	93.0	93.1	91.8	92.0	No MTO
1S	0.3	0.3	1.0	0.9	0.4	0.4	0.5	0.5	precision
D2S	1.0	1.0	2.9	2.6	1.2	1.2	1.4	1.5	statements for
n/Outliers	71/5		88/2		79/9		82/3		this test

A – AMRL reports percent passing inch series equivalent sieves.

σ* - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 43	2012		2013		2014		2015		MTO LS-702
P 20 µm	5.12	6.12	5.13	6.13	5.14	6.14	5.15	6.15	
Mean	80.6	80.6	79.3	79.3	85.4	85.9	82.3	82.7	No MTO
1S	4.2	4.2	3.4	3.1	2.7	2.7	3.3	3.3	precision
D2S	12.0	12.0	9.5	8.7	7.6	7.6	9.4	9.3	statements for
n/Outliers	74/2		85/5		80/8		83/2		this test

Test 44	2012		2013		2014		2015		MTO LS-702
P 5 µm	5.12	6.12	5.13	6.13	5.14	6.14	5.15	6.15	
Mean	43.7	43.9	59.4	58.9	76.1	76.9	72.9	73.2	No MTO
1S	2.7	2.6	3.4	3.1	3.0	3.0	3.0	3.1	precision
D2S	7.7	7.2	9.6	8.7	8.6	8.6	8.4	8.9	statements for
n/Outliers	71/5		84/6		78/10		83/2		this test

Test 45	2012		2013		2014		2015		MTO LS-702
P 2 µm	5.12	6.12	5.13	6.13	5.14	6.14	5.15	6.15	
Mean	28.6	28.8	43.9	43.9	65.5	66.1	62.6	63.2	No MTO
1S	2.3	2.3	2.4	2.8	3.2	3.2	3.3	3.1	precision
D2S	6.6	6.6	6.8	8.0	8.9	8.9	9.3	8.9	statements for
n/Outliers	72/4		81/9		78/10		83/2		this test

Test 46	2012		2013		2014		2015		ASTM D4318
L. L	5.12	6.12	5.13	6.13	5.14	6.14	5.15	6.15	
Mean	32.2	32.2	37.1	37.1	48.1	48.3	47.4	47.6	59.9
1S	1.2	1.2	1.3	1.4	1.9	2.2	1.9	2.3	2.1
D2S	3.3	3.3	3.8	3.9	5.5	6.3	5.4	6.6	6
n/Outliers	89/6		103/5		99/9		97/5		

Test 47	2012		2013		2014		2015		ASTM D4318
P. L	5.12	6.12	5.13	6.13	5.14	6.14	5.15	6.15	
Mean	18.9	18.9	18.8	18.7	21.2	21.2	21.2	21.3	20.4
1S	1.1	1.1	1.3	1.1	1.6	1.6	1.5	1.5	2.7
D2S	3.1	3.1	3.6	3.2	4.7	4.7	4.2	4.3	7
n/Outliers	86/9		104/4		101/7		99/3		

Test 48	2012		2013		2014		2015		ASTM D4318
P. I	5.12	6.12	5.13	6.13	5.14	6.14	5.15	6.15	
Mean	13.3	13.4	18.4	18.3	26.8	27.0	26.5	26.4	39.5
1S	1.7	1.7	1.6	1.4	1.9	2.3	2.2	2.5	3.1
D2S	4.8	4.8	4.5	4.1	5.5	6.5	6.3	6.9	9
n/Outliers	93/2		101/7		102/6		99/3		

Test 49	2012		2013		2014		2015		AASHTO T 100
SG of Soils	5.12	6.12	5.13	6.13	5.14	6.14	5.15	6.15	
Mean	2.721	2.718	2.733	2.734	2.755	2.758	2.747	2.751	
1S	0.023	0.023	0.024	0.025	0.030	0.031	0.026	0.026	0.04
D2S	0.065	0.065	0.068	0.071	0.085	0.088	0.074	0.074	0.11
n/Outliers	60/10		74/9		82/7		72/13		

A – AMRL reports percent passing inch series equivalent sieves.

σ^{*} - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Test 95	2012		2013		2014		2015		AASHTO T 304
UC Void	3.12	4.12	3.13	4.13	3.14	4.14	3.15	4.15	
Mean	44.0	44.1	42.2	42.3	42.8	42.8	43.6	43.7	
1S	0.66	0.63	0.64	0.65	0.60	0.48	0.52	0.49	0.33%
D2S	1.86	1.78	1.80	1.85	1.71	1.37	1.46	1.38	0.93%
n/Outliers	66/5		71/1		62/2		56/8		

Test 96	2012		2013		2014		2015		ASTM D2419
SE Value	3.12	4.12	3.13	4.13	3.14	4.14	3.15	4.15	
Mean	32.5	32.0	42.8	42.7	66.3	66.1	53.7	53.3	
1S	3.62	3.67	8.0	7.7	4.9	4.9	8.6	8.7	< 80
D2S	10.24	10.38	22.7	21.8	14.0	14.0	24.5	24.6	8.0
n/Outliers	65/2		68/0		59/2		62/0		22.6

Test 97	2012		2013		2014		2015		ASTM D5821
% Fractured	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	
Mean	78.5	78.8	71.4	71.4	79.0	79.2	66.7	66.9	
1S	5.4	6.4	4.6	4.3	2.3	2.5	4.7	4.3	76.0%
D2S	15.4	18.1	12.9	12.2	6.4	7.0	13.4	12.2	5.2%
n/Outliers	70/2		72/2		64/4		63/7		14.7%

Test 99	2012		2013		2014		2015		ASTM D4791
% F & E	1.12	2.12	1.13	2.13	1.14	2.14	1.15	2.15	
Mean	0.66	0.55	1.43	1.43	1.12	1.13	0.77	0.77	
1S	0.46	0.32	0.80	0.78	0.61	0.65	0.42	0.43	19.0 -12.5 mm
D2S	1.30	0.89	2.27	2.21	1.72	1.84	1.18	1.23	88.5%
n/Outliers	66/6		72/2		66/2		58/12		250.3%

Test 15	2014		2015		2016		2017		ASTM D3042
% Residue	3.14	4.14	3.15	4.15	3.16	4.16	3.17	4.17	
Mean	40.2	41.1	47.5	48.2					
1S	8.8	6.7	1.7	2.3					48.2%
D2S	24.9	19.1	4.9	6.5					2.7
n/Outliers	15/1		12/2						7.7

Test 98	2014		2015		2016		2017		ASTM D3042
% Retained	3.14	4.14	3.15	4.15	3.16	4.16	3.17	4.17	
Mean	39.0	36.8	46.0	46.7					
1S	2.4	4.0	2.0	2.7					3.1
D2S	6.7	11.2	5.6	7.7					8.9
n/Outliers	11/5		13/1						

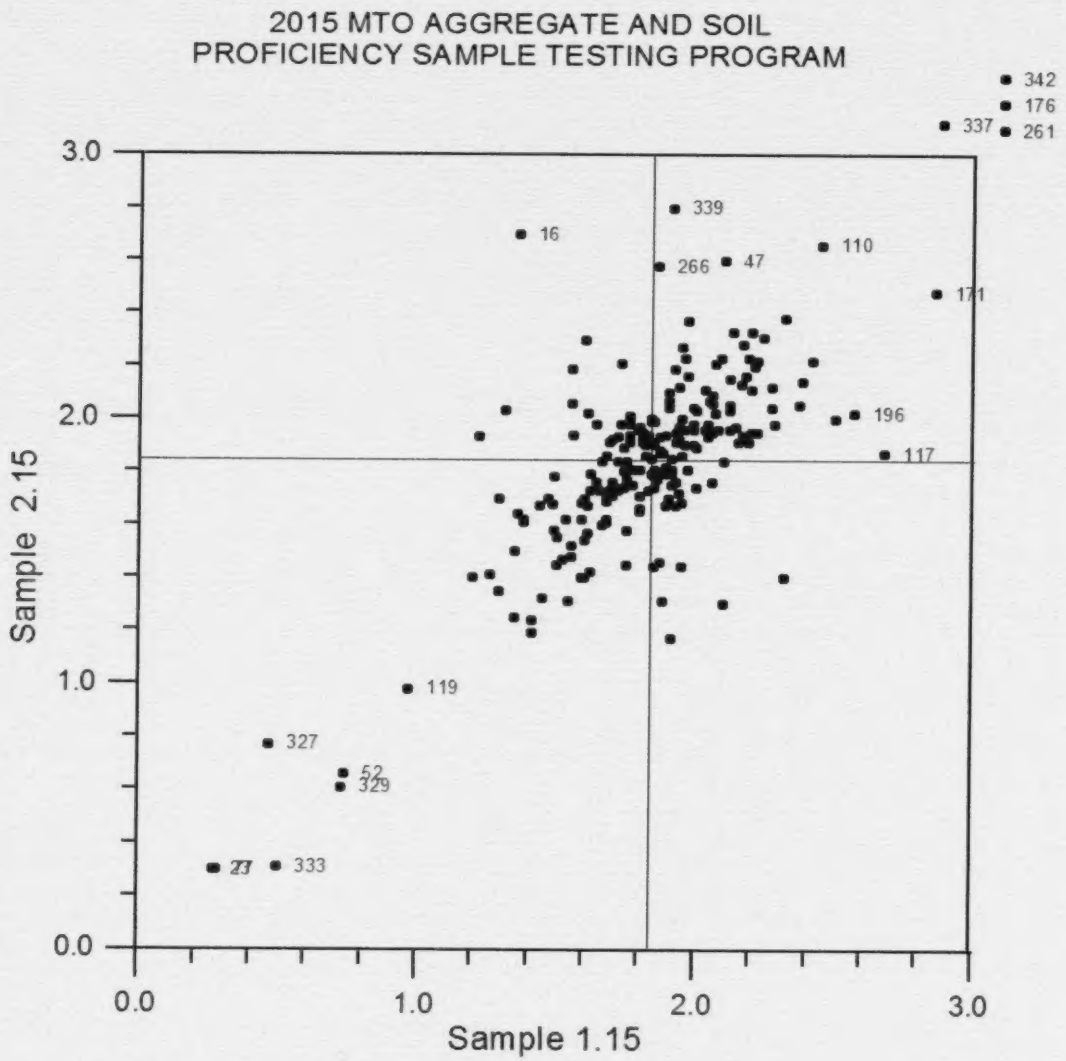
Test 123*	2004		2010		2015				ASTM C1260
Mortar Bar	1.04	2.04	1.10	2.10	1.15	2.15			C of V
Mean	0.196	0.410	0.191	0.373	0.173	0.179			
1S	0.035	0.051	0.028	0.045	0.030	0.036			Expansion >0.1%
D2S	0.099	0.144	0.079	0.127	0.085	0.102			15.2%
n/Outliers	16/0		19/1		22/2				43%

* – Test 123 was conducted in 2004, 2010 and 2015 only.

A – AMRL reports percent passing inch series equivalent sieves.

σ' - Calculated from Coefficient of Variation Precision Statement (Coefficient of Variation = Standard Deviation / Mean)

Appendix D1: Scatter Diagrams



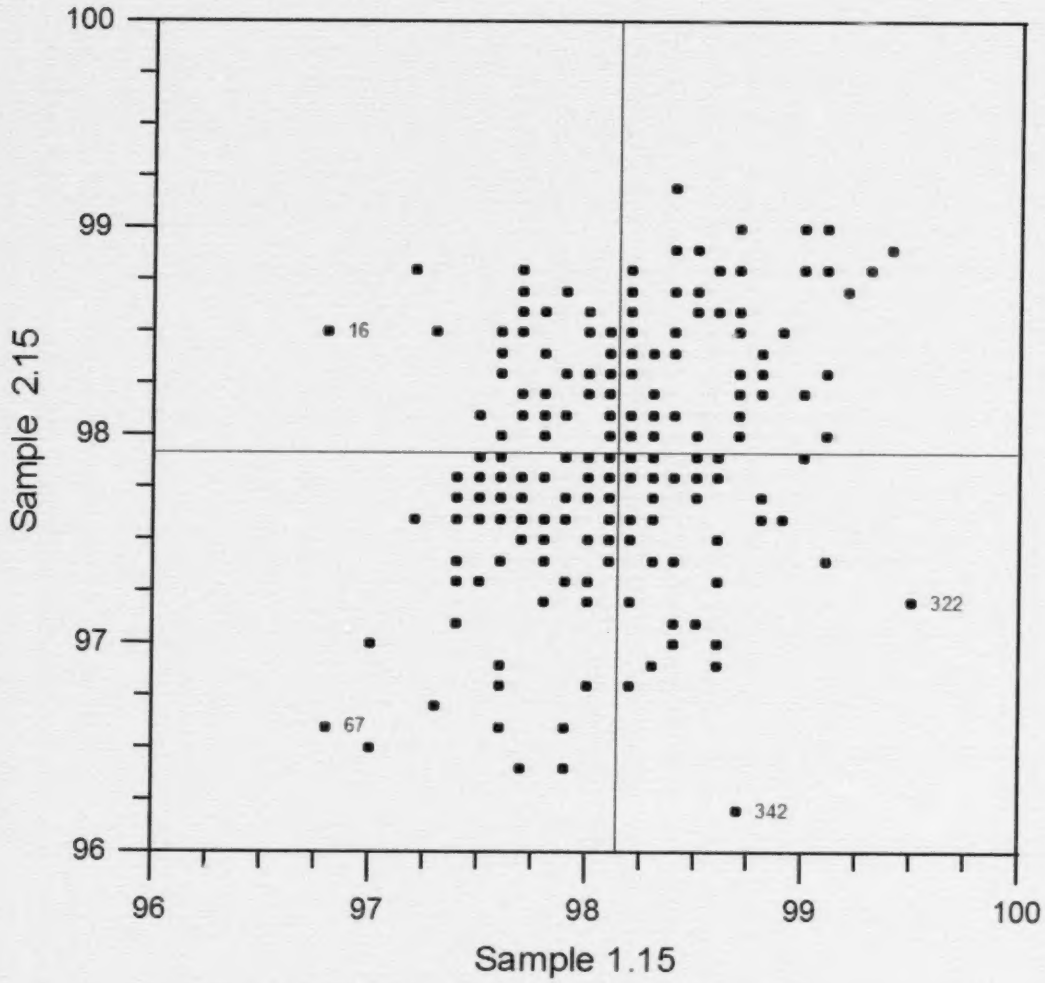
Test 1: Wash Pass 75 um

	Mat 1	Mat 2
Mean	1.838	1.844
Median	1.850	1.775
Std Dev	0.251	0.247

n = 207

Labs Eliminated: 16; 23; 47; 52; 77; 110; 117; 119; 171; 176; 196; 261; 266; 327; 329; 333; 337; 339; 342

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



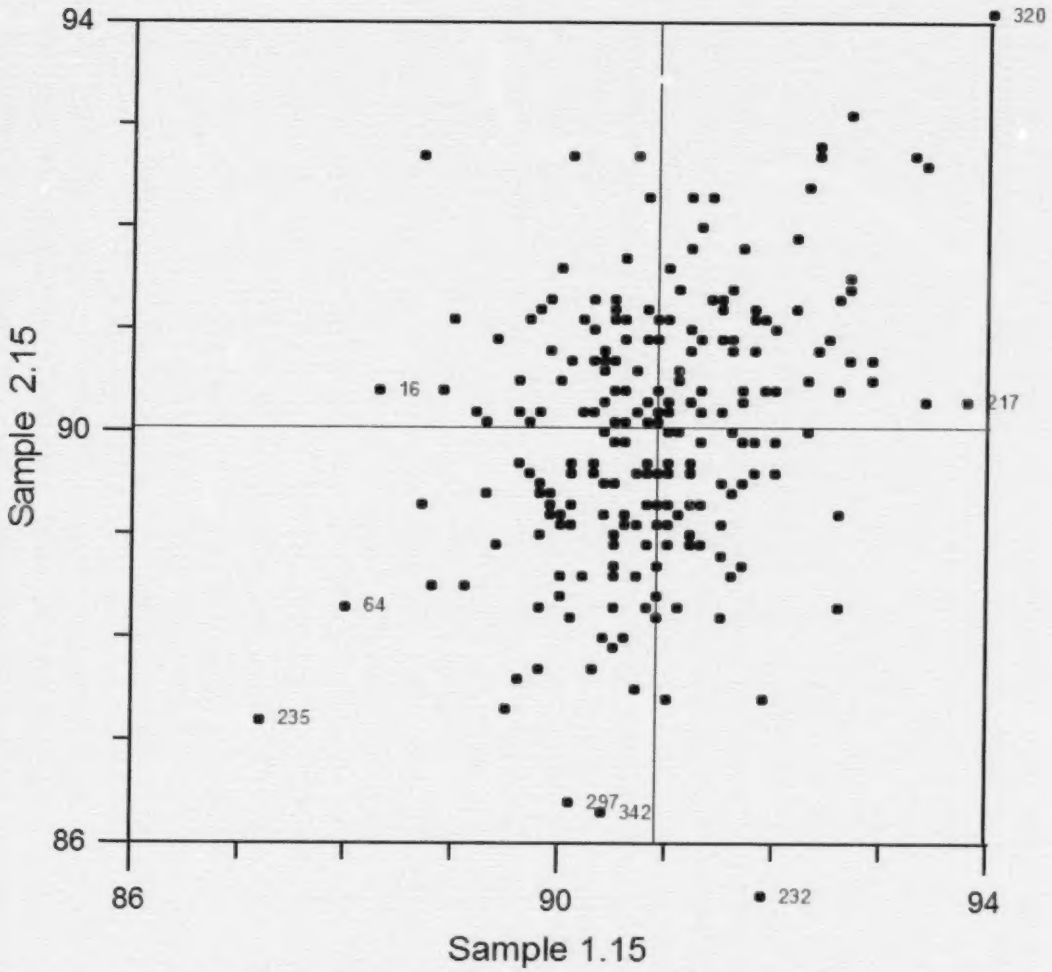
Test 2: Percent Passing the 19.0 mm Sieve

	Mat 1	Mat 2
Mean	98.143	97.921
Median	98.200	97.800
Std Dev	0.4638	0.5560

n = 222

Labs Eliminated: 16; 67; 322; 342

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



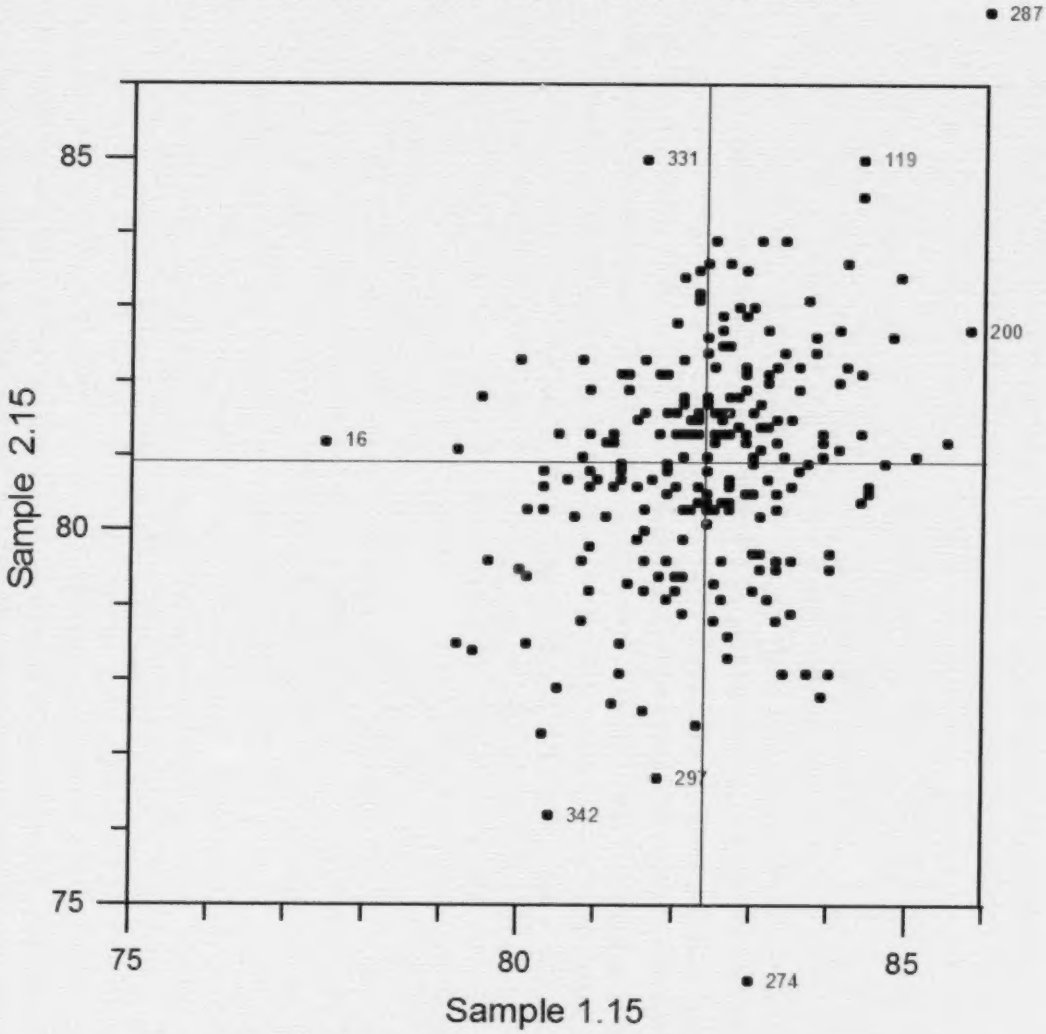
Test 3: Percent Passing the 16.0 mm Sieve

	Mat 1	Mat 2
Mean	90.898	90.047
Median	91.050	90.200
Std Dev	0.9125	1.1942

n = 218

Labs Eliminated: 16; 64; 217; 232; 235; 297; 320; 342

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



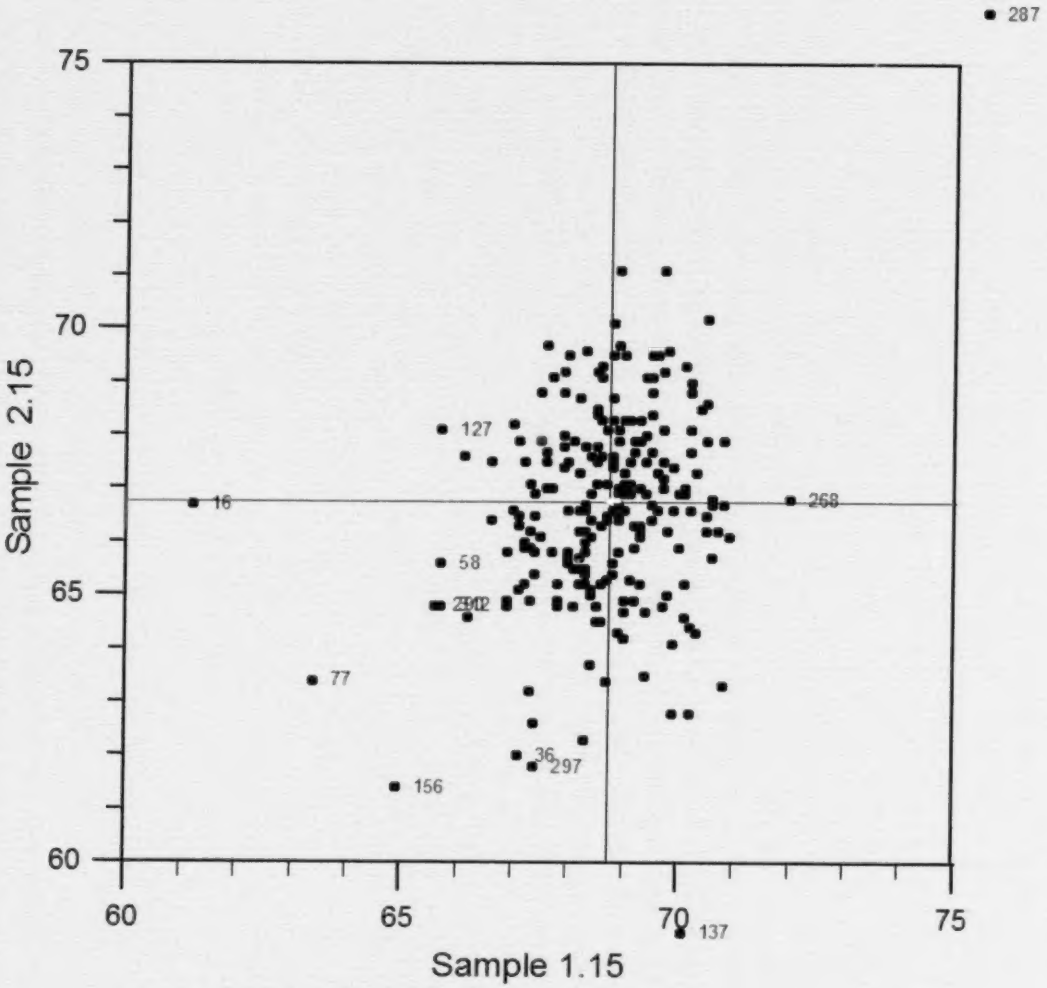
Test 4: Percent Passing the 13.20 mm Sieve

	Mat 1	Mat 2
Mean	82.380	80.930
Median	82.350	80.900
Std Dev	1.1784	1.4058

n = 218

Labs Eliminated: 16; 119; 200; 274; 287; 297; 331; 342

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



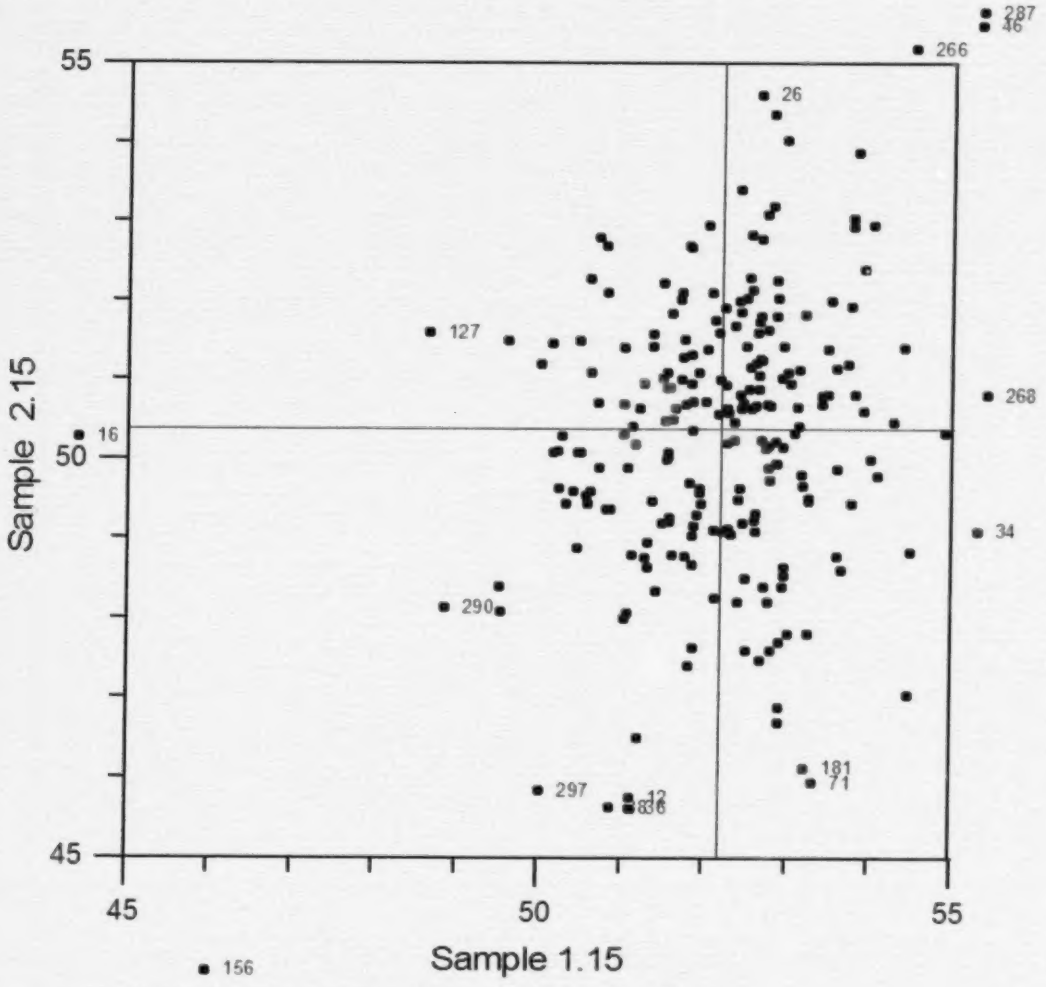
Test 5: Percent Passing the 9.5 mm Sieve

	Mat 1	Mat 2
Mean	68.753	66.755
Median	68.500	66.700
Std Dev	1.0277	1.6554

n = 214

Labs Eliminated: 16; 36; 58; 77; 127; 137; 156; 268; 287; 290; 297; 312

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



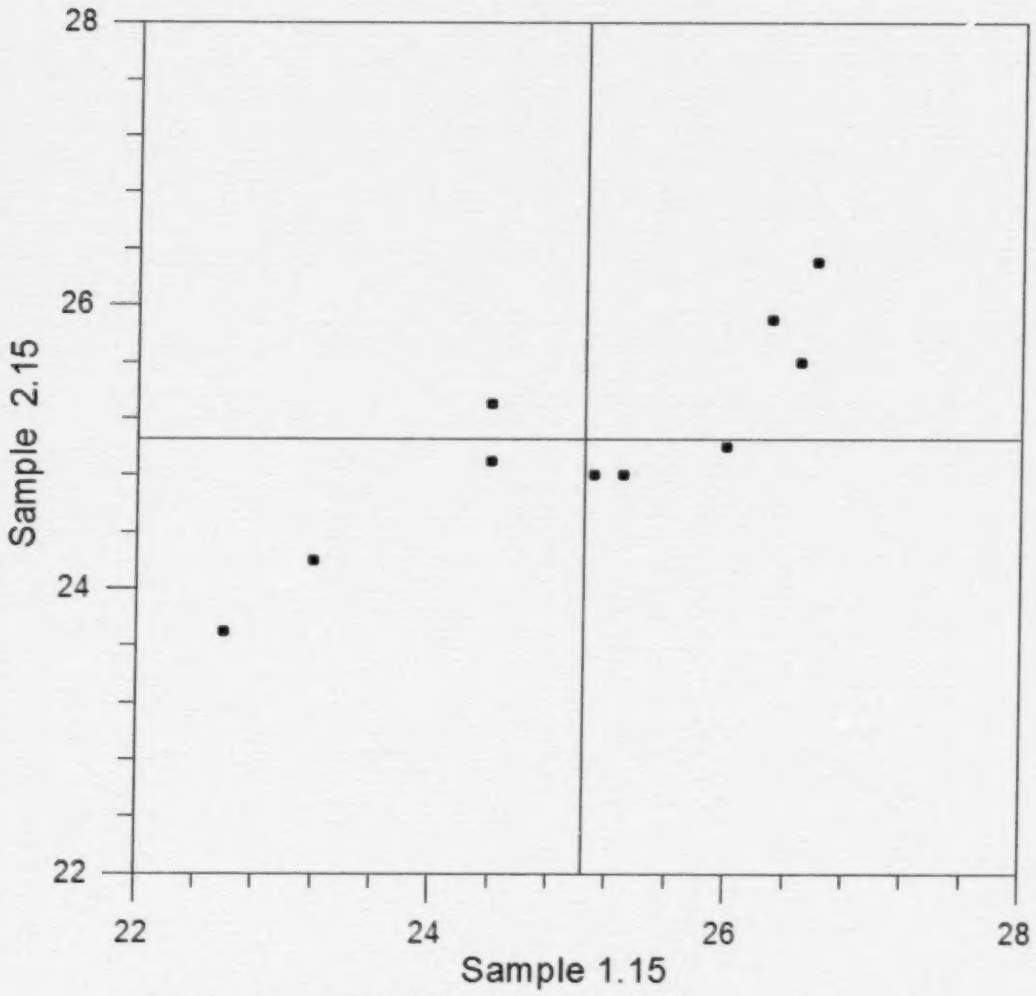
Test 6: Percent Passing the 4.75 mm Sieve

	Mat 1	Mat 2
Mean	52.184	50.386
Median	52.200	50.430
Std Dev	1.0595	1.4794

n = 210

Labs Eliminated: 12; 16; 26; 34; 36; 38; 46; 71; 127; 156; 181; 266; 268; 287; 290; 297

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



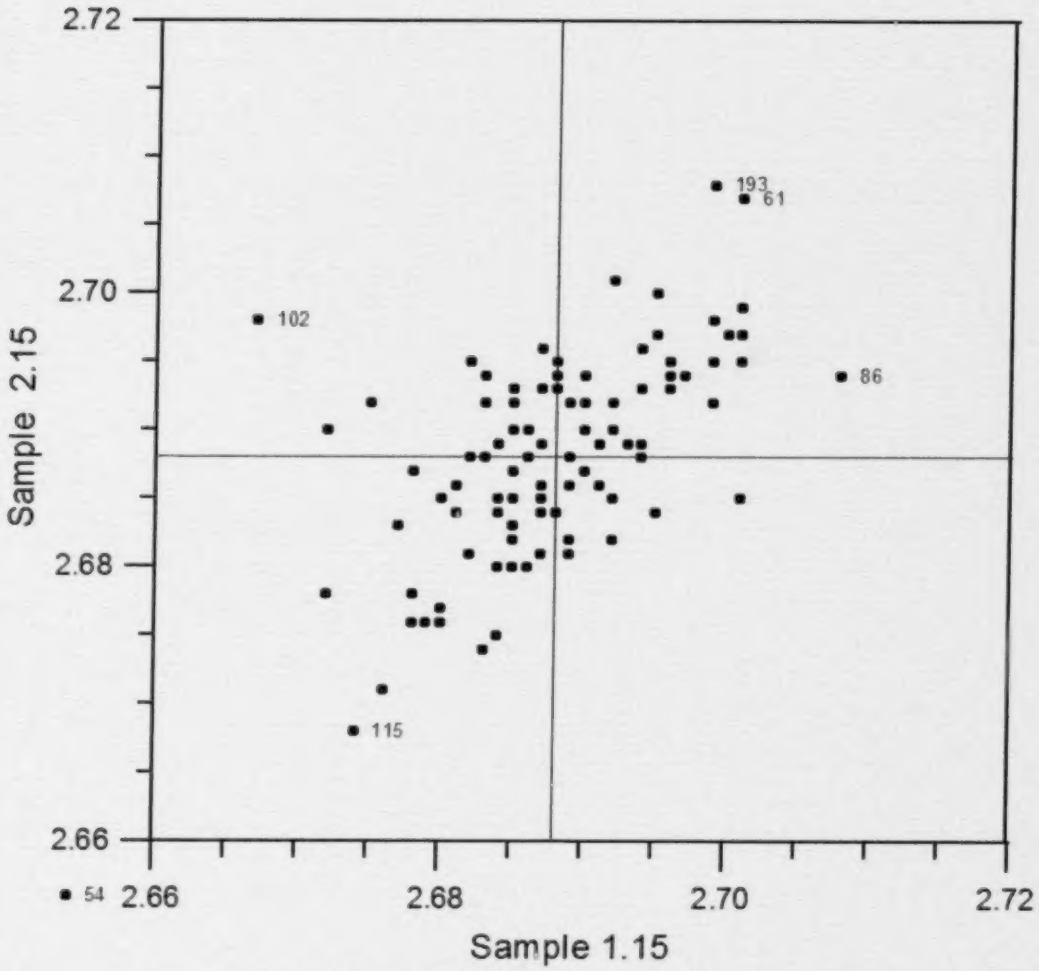
Test 8: Los Angeles Abrasion Loss, %

	Mat 1	Mat 2
Mean	25.040	25.050
Median	24.600	25.000
Std Dev	1.3866	0.7706

n = 10

Labs Eliminated: None

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



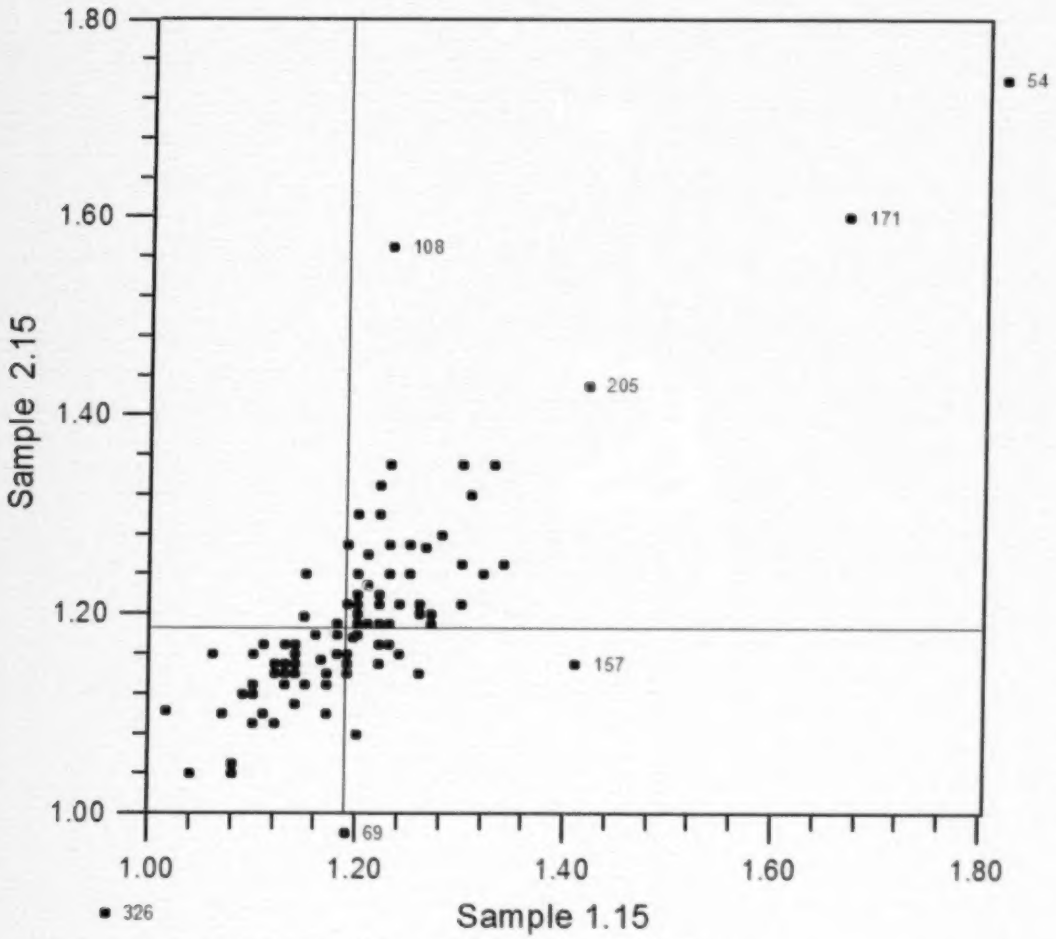
Test 9: Relative Density of Coarse Aggregate (O. D)

	Mat 1	Mat 2
Mean	2.688	2.688
Median	2.687	2.686
Std Dev	0.007	0.006

n = 93

Labs Eliminated: 54; 61; 86; 102; 115; 193

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



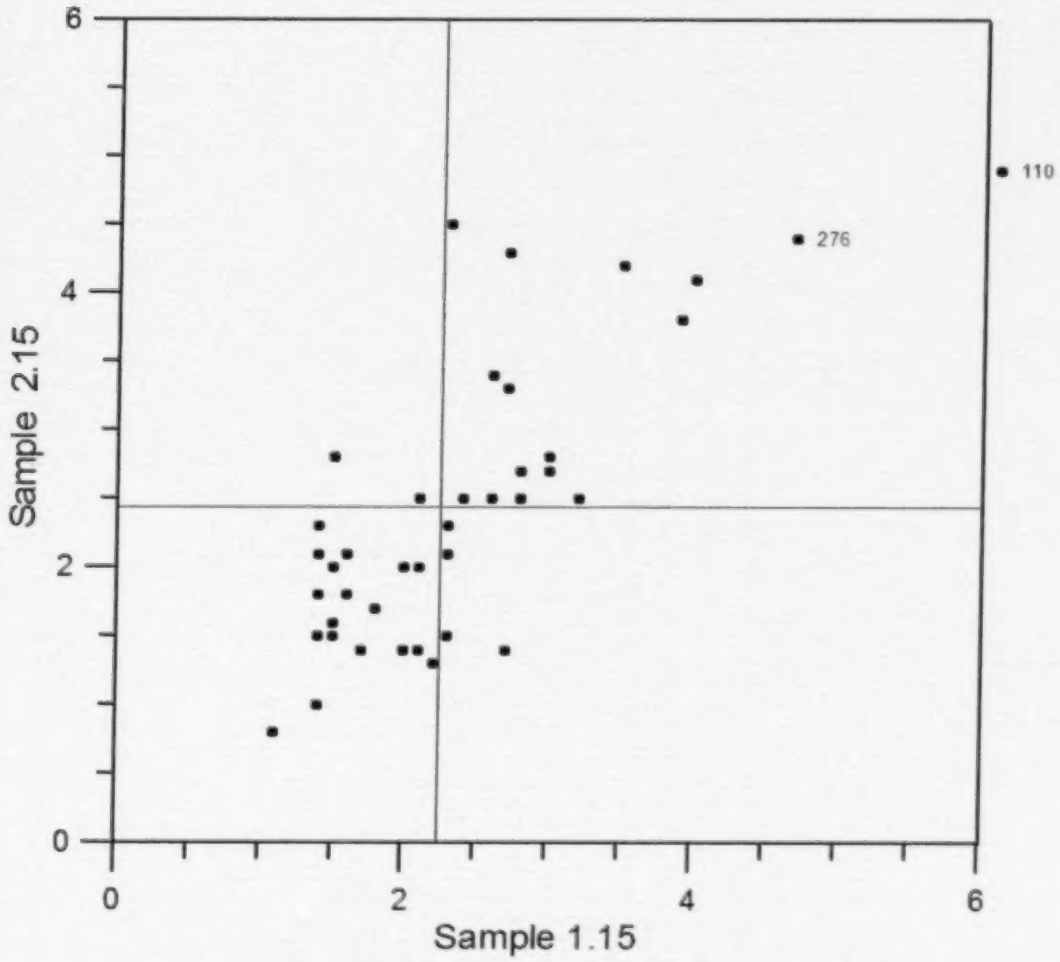
Test 10: Absorption of Coarse Aggregate

	Mat 1	Mat 2
Mean	1.188	1.186
Median	1.178	1.195
Std Dev	0.066	0.067

n = 92

Labs Eliminated: 54; 69; 108; 157; 171; 205; 326

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



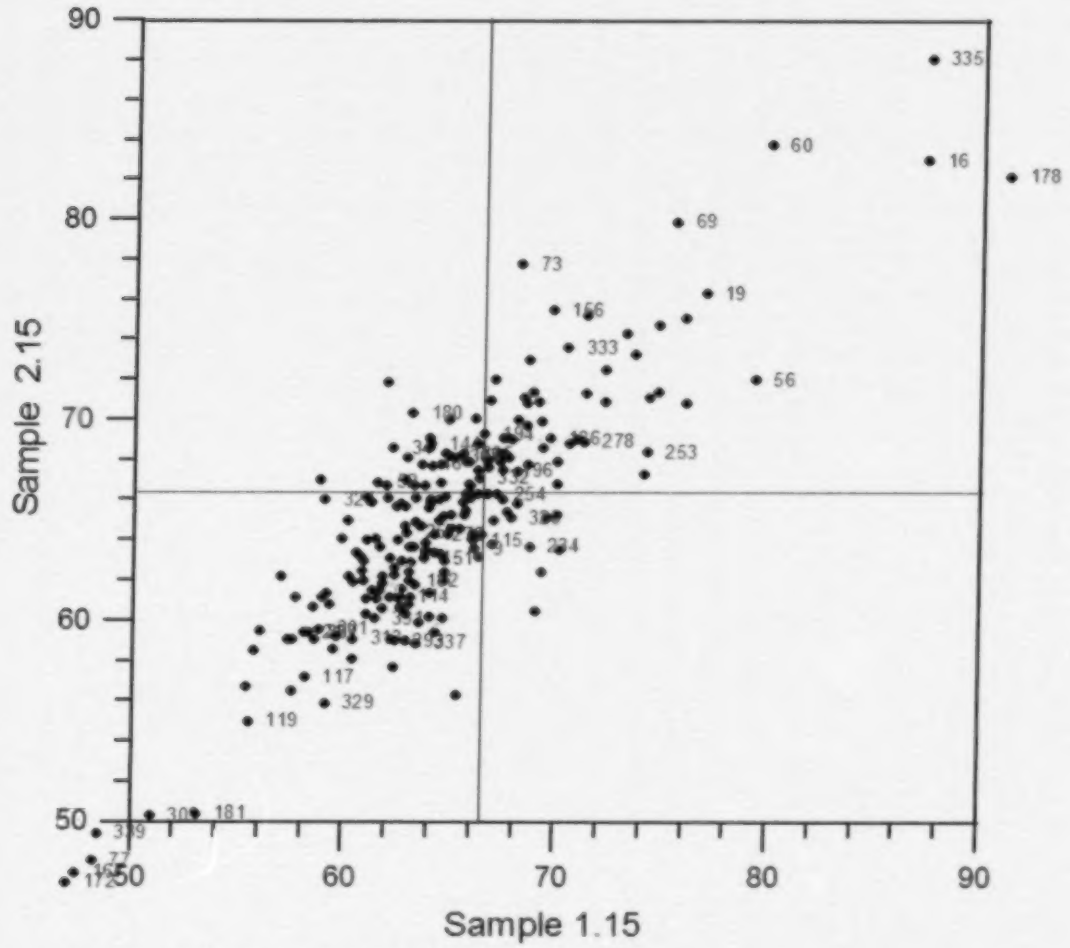
Test 11: MgSO4 Soundness of Coarse Aggregate, % Loss

	Mat 1	Mat 2
Mean	2.250	2.443
Median	2.550	2.650
Std Dev	0.762	1.064

n = 40

Labs Eliminated: 110, 276

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



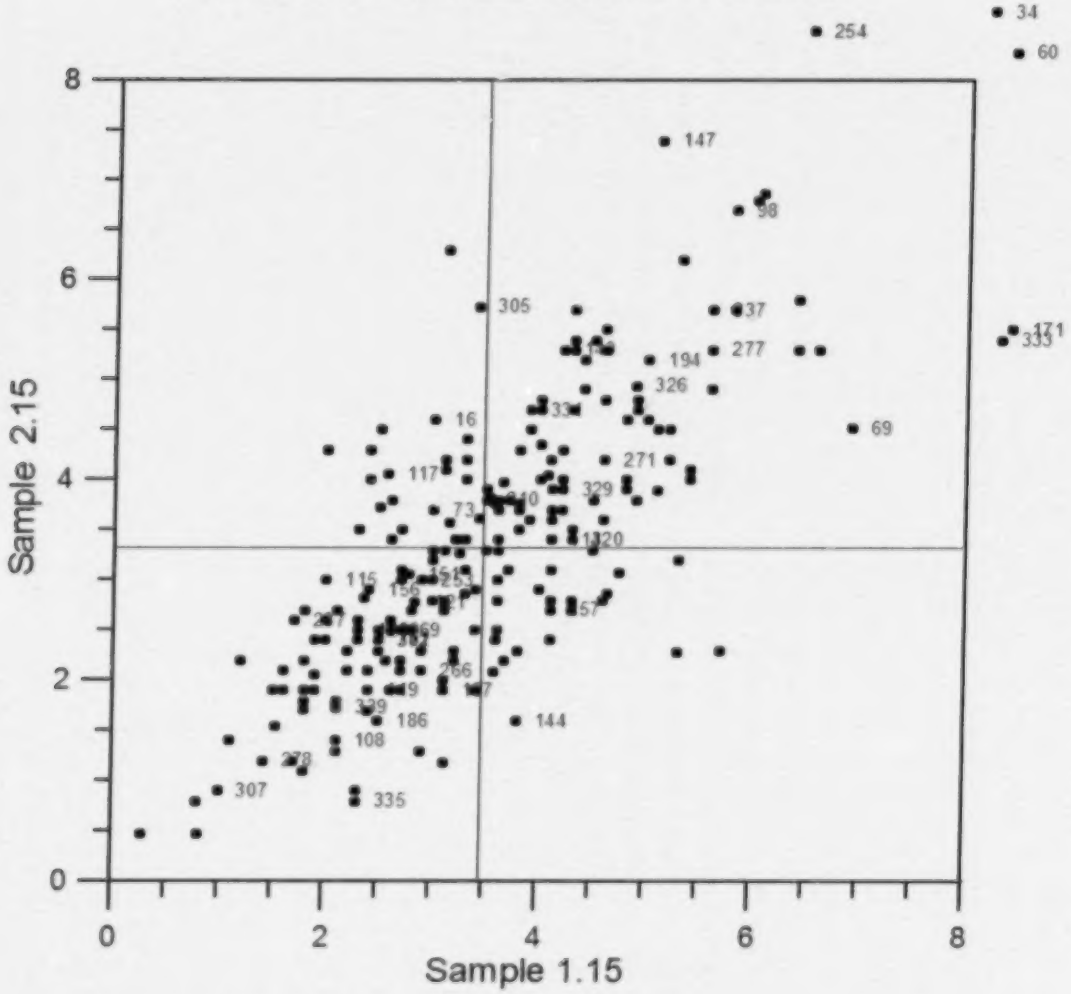
Test 12: Percent Crushed Particles

	Mat 1	Mat 2
Mean	64.611	65.186
Median	65.700	65.750
Std Dev	4.1669	4.0598

n = 176

Labs Eliminated: 9; 16; 19; 21; 34; 46; 52; 56; 60; 69; 73; 77; 114; 115; 117; 119; 144; 151; 156; 167; 172; 178; 180; 181; 182; 186; 194; 196; 234; 253; 254; 257; 272; 278; 287; 293; 301; 305; 307; 309; 313; 320; 327; 329; 331; 332; 333; 335; 337; 339

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



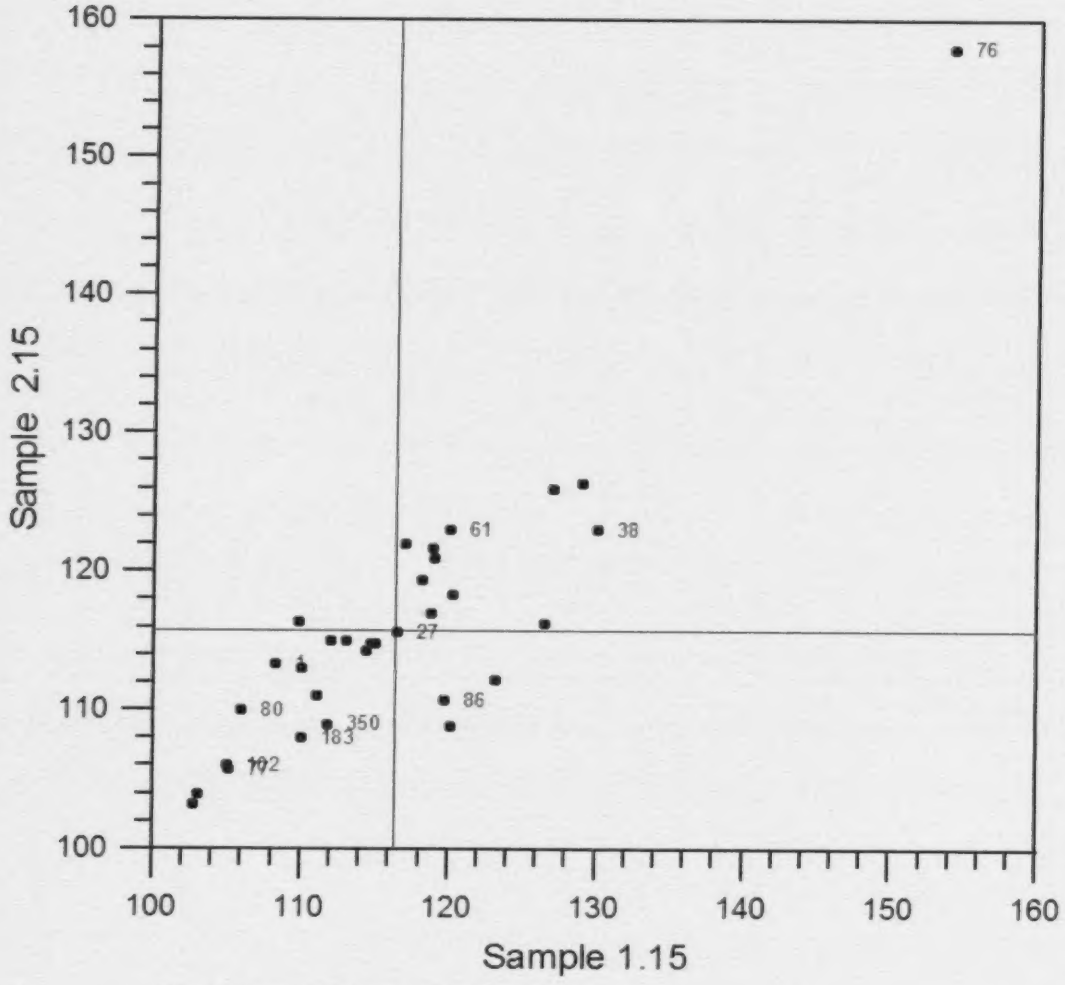
Test 13: Percent Flat and Elongated Particles

	Mat 1	Mat 2
Mean	3.469	3.320
Median	3.440	3.670
Std Dev	1.210	1.252

n = 180

Labs Eliminated: 9; 16; 34; 60; 69; 73; 77; 98; 107; 108; 114; 115; 117; 119; 120; 121; 140; 144; 147; 151; 156; 171; 186; 194; 196; 210; 253; 254; 257; 266; 271; 277; 278; 287; 301; 305; 307; 320; 326; 329; 331; 332; 333; 335; 337; 339

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



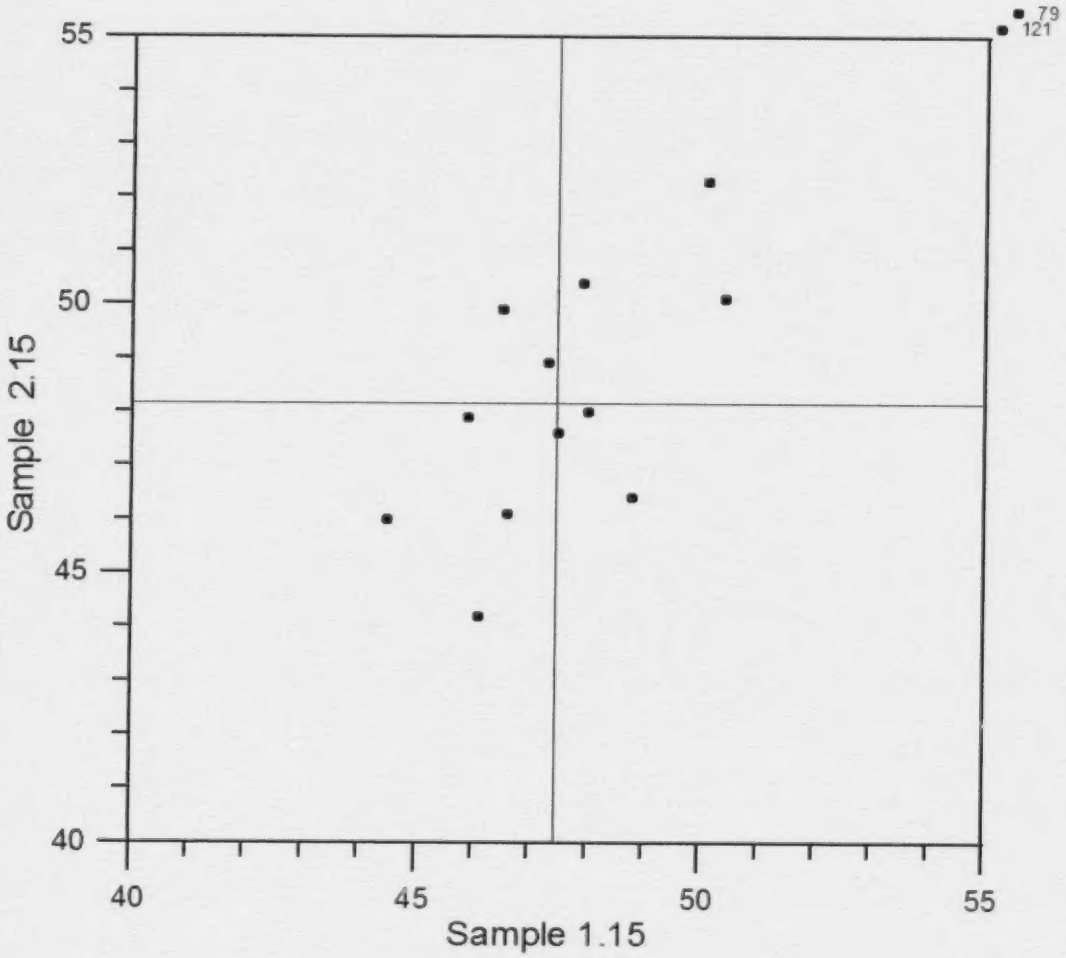
Test 14: Petrographic Number

	Mat 1	Mat 2
Mean	116.362	115.752
Median	115.85	114.8
Std Dev	7.034	6.056

n = 21

Labs Eliminated Number: 1; 27; 38; 61; 76; 77; 80; 86; 102; 183; 350

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



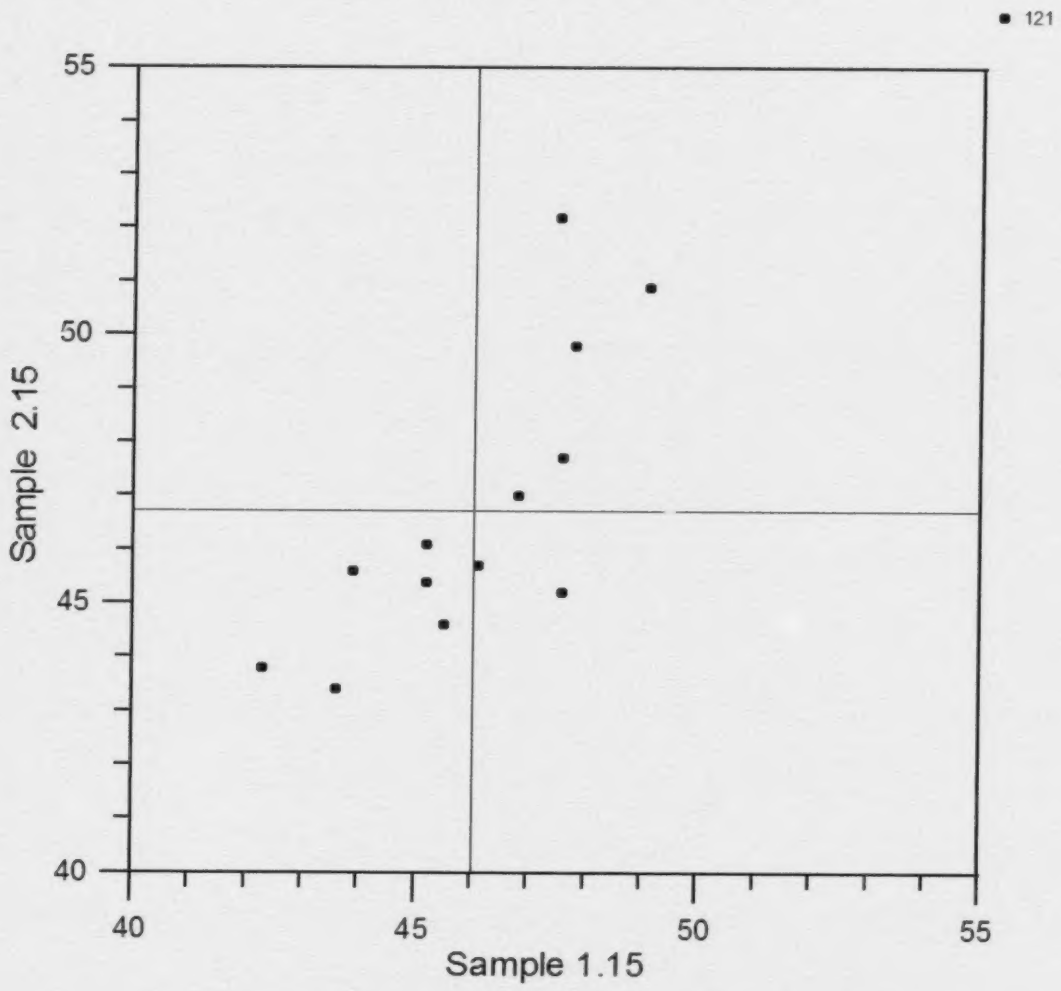
Test 15: Total Percentage of Insoluble Residue

	Mat 1	Mat 2
Mean	47.467	48.150
Median	47.450	48.250
Std Dev	1.7222	2.2881

n = 12

Lab Eliminated: 79; 121

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



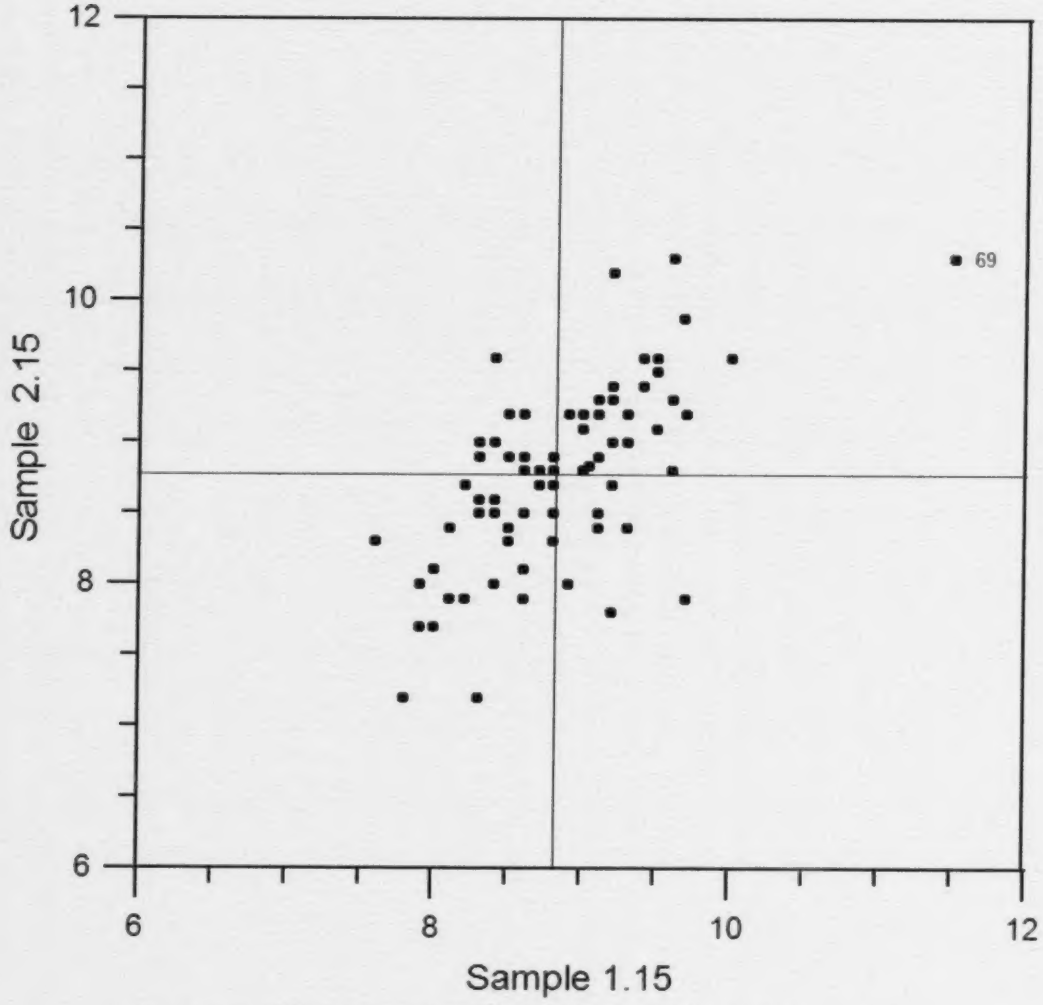
Test 98: Percentage of Insoluble Residue Retained 75µm

	Mat 1	Mat 2
Mean	46.015	46.723
Median	45.700	47.800
Std Dev	1.9634	2.7203

n = 13

Labs Eliminated: 121

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



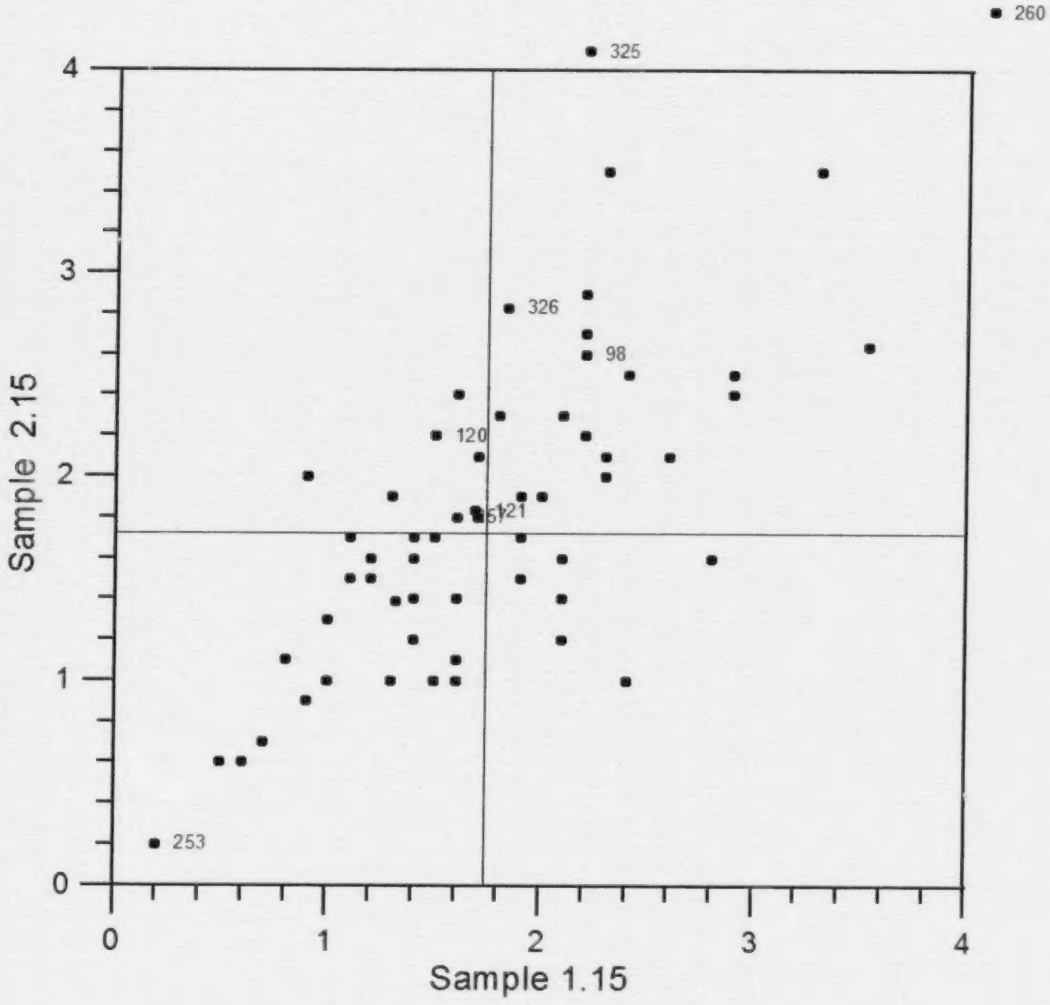
Test 16: Micro-Deval Abrasion Loss (CA), %

	Mat 1	Mat 2
Mean	8.818	8.776
Median	8.800	8.750
Std Dev	0.518	0.631

n = 78

Labs Eliminated: 69

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



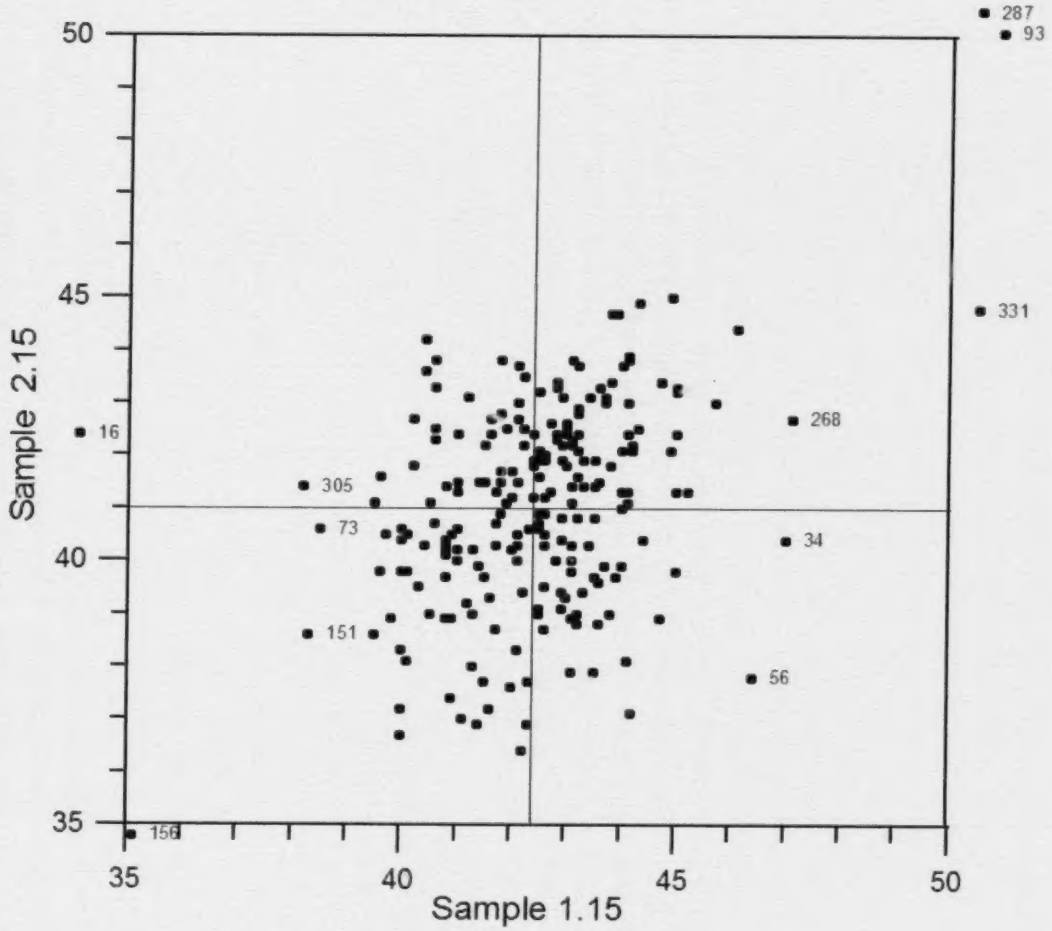
Test 17: Freeze-Thaw Loss, %

	Mat 1	Mat 2
Mean	1.742	1.720
Median	2.015	2.050
Std Dev	0.680	0.667

n = 52

Labs Eliminated: 98; 120; 121; 253; 257; 260; 325; 326

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



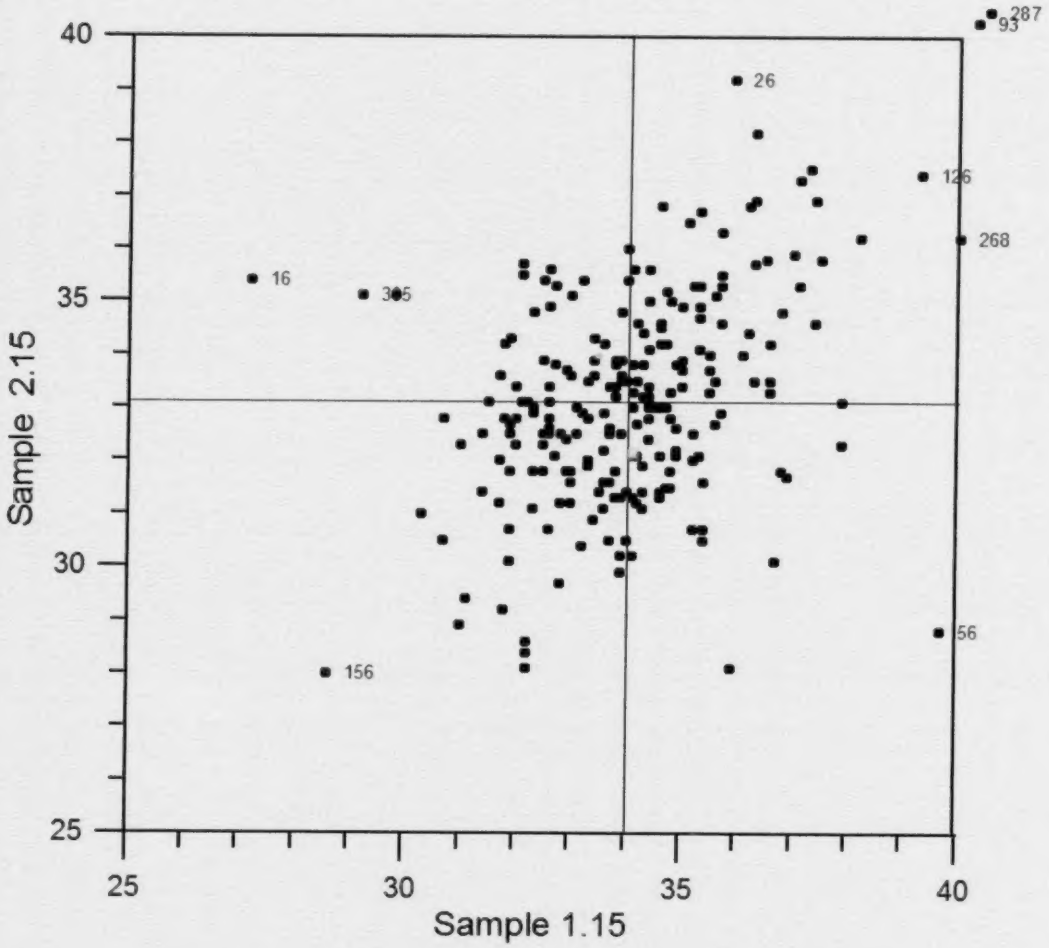
Test 20: Percent Passing the 2.36 mm Sieve

	Mat 1	Mat 2
Mean	42.382	40.992
Median	42.800	40.700
Std Dev	1.3743	1.8314

n = 215

Labs Eliminated: 16; 34; 56; 73; 93; 151; 156; 268; 287; 305; 331

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



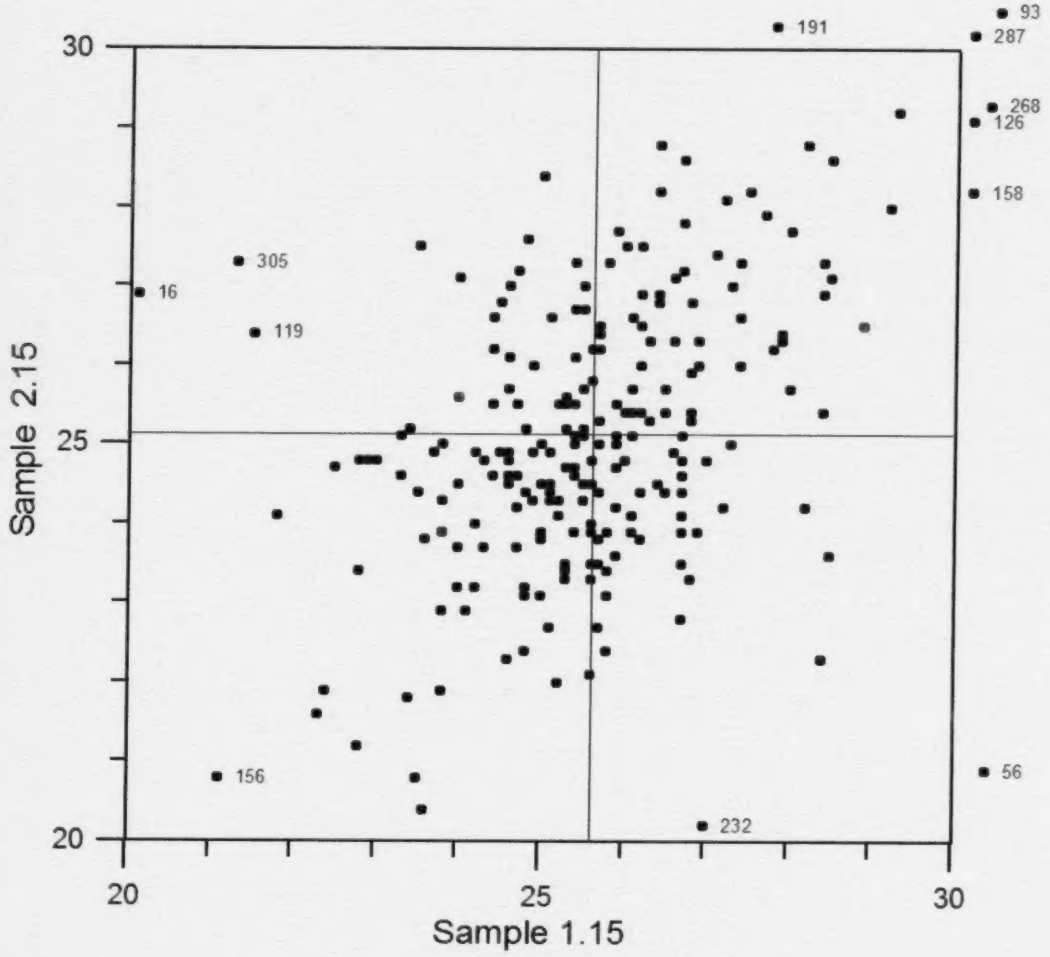
Test 21: Percent Passing the 1.18 mm Sieve

	Mat 1	Mat 2
Mean	34.035	33.105
Median	34.000	33.150
Std Dev	1.5999	1.9313

n = 217

Labs Eliminated: 16; 26; 56; 93; 126; 156; 268; 287; 305

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



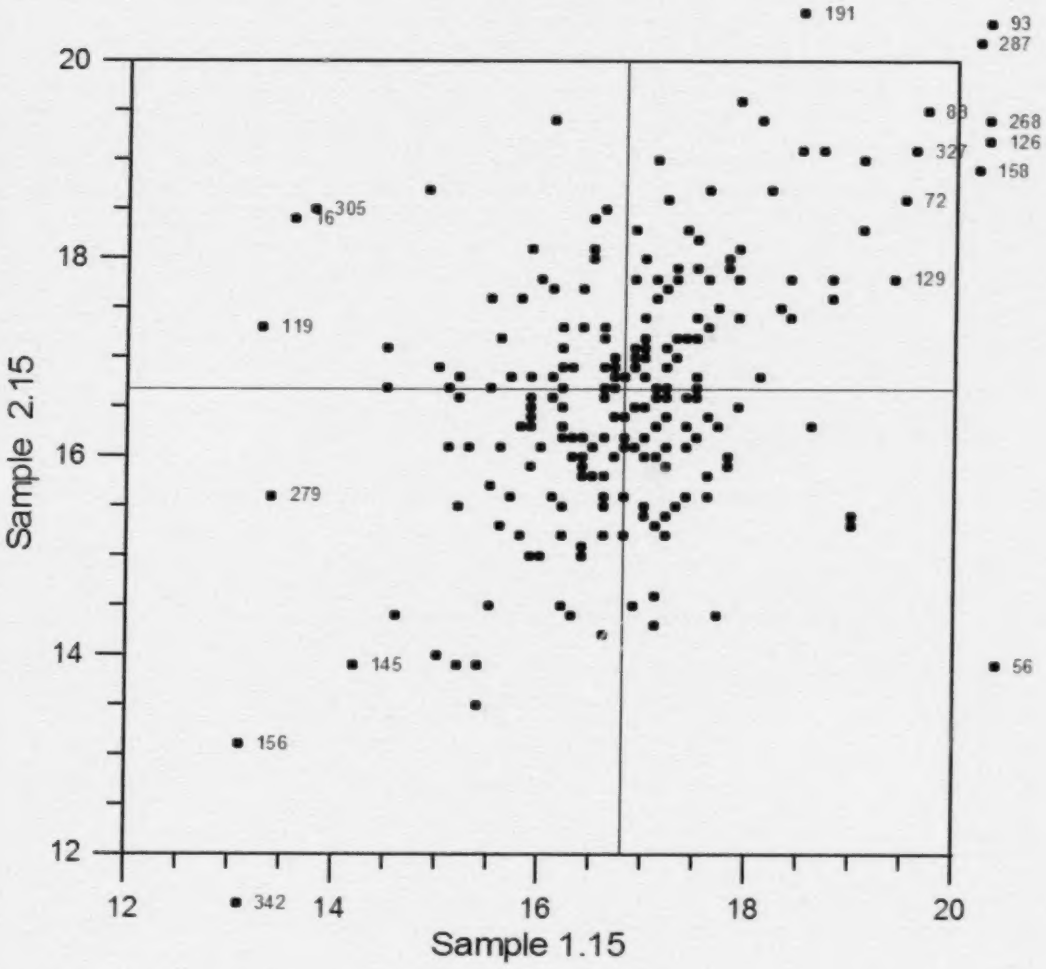
Test 22: Percent Passing the 600 um Sieve

	Mat 1	Mat 2
Mean	25.616	25.127
Median	25.550	24.800
Std Dev	1.3900	1.7261

n = 214

Labs Eliminated: 16; 56; 93; 119; 126; 156; 158; 191; 232; 268; 287; 305

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



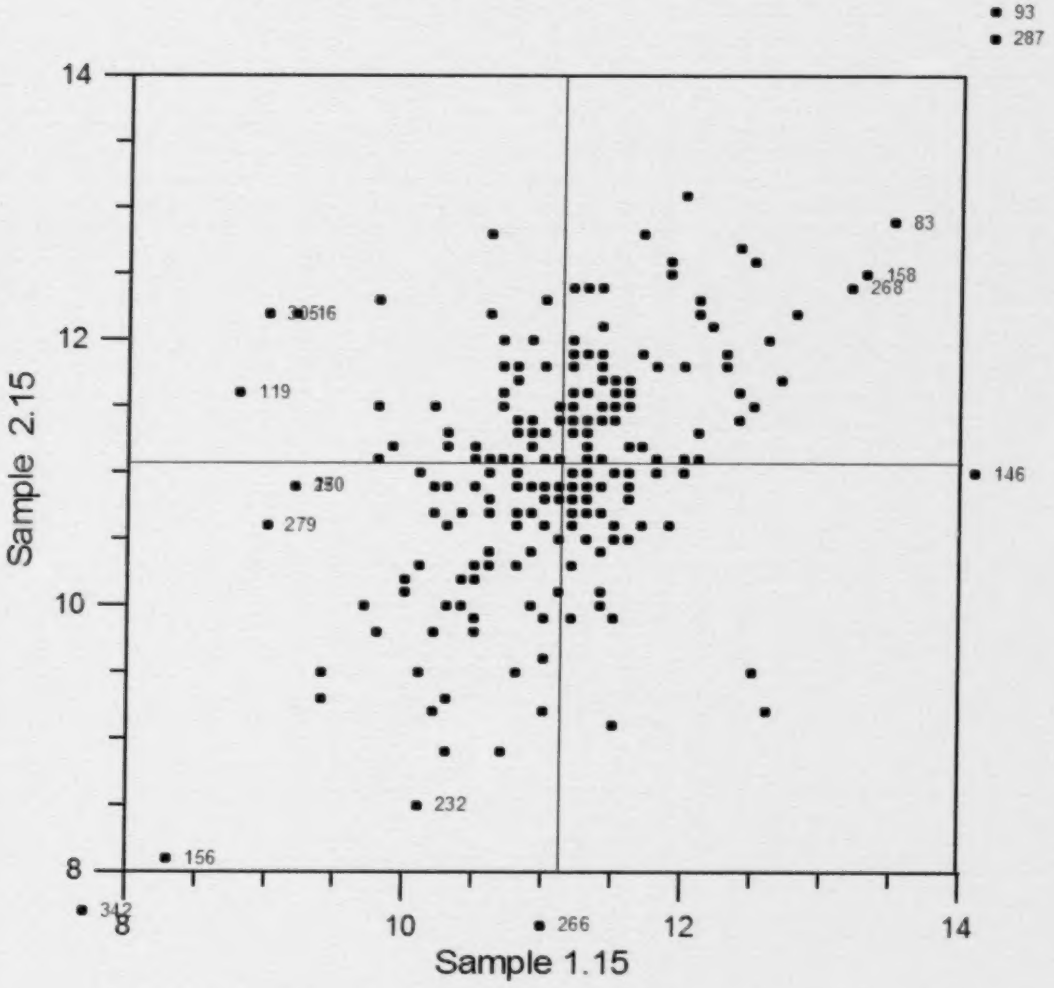
Test 23: Percent Passing the 300 um Sieve

	Mat 1	Mat 2
Mean	16.793	16.680
Median	16.800	16.550
Std Dev	0.8987	1.2254

n = 208

Labs Eliminated: 16; 56; 72; 83; 93; 119; 126; 129; 145; 156; 158; 191; 268; 279; 287; 305; 327; 342

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



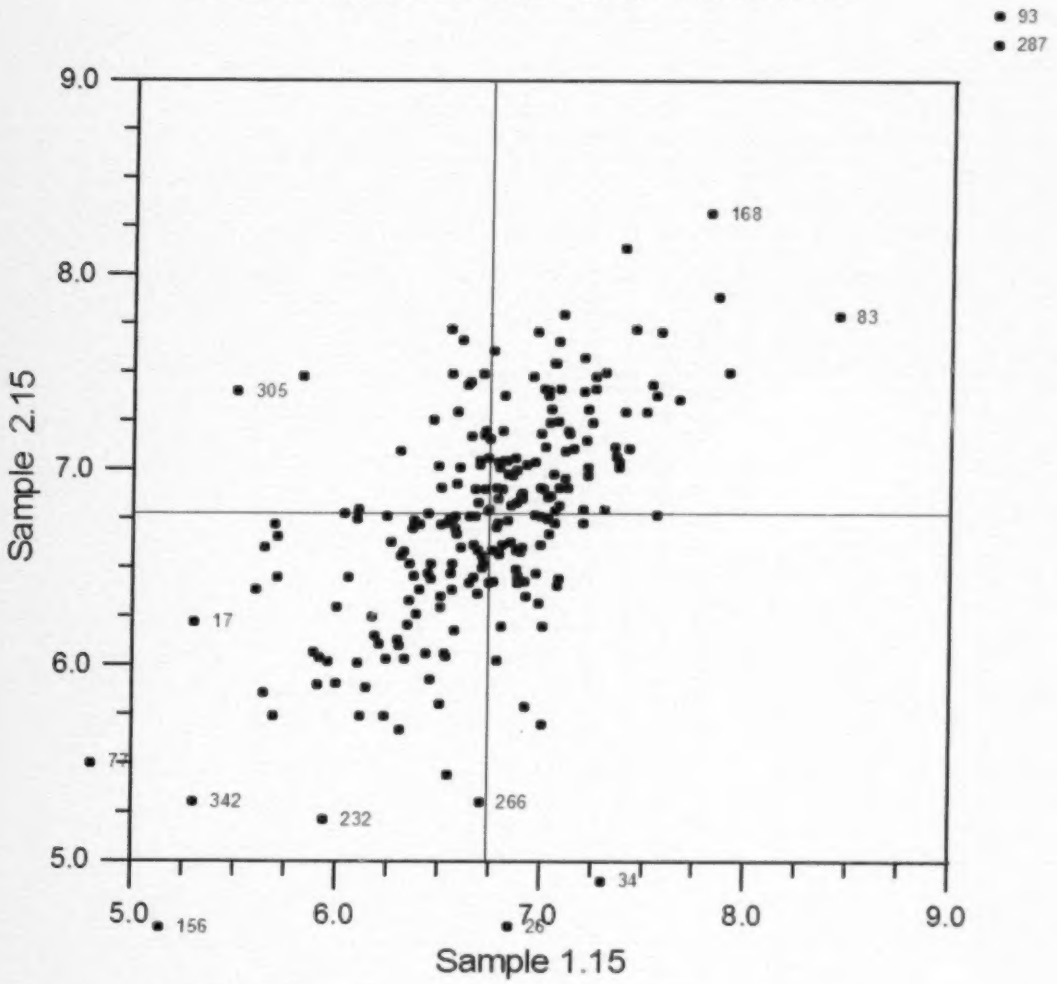
Test 24: Percent Passing the 150 um Sieve

	Mat 1	Mat 2
Mean	11.127	11.074
Median	11.100	11.000
Std Dev	0.6459	0.8317

n = 210

Labs Eliminated: 16; 17; 83; 93; 119; 146; 156; 158; 232; 250; 266; 268; 279; 287; 305; 342

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



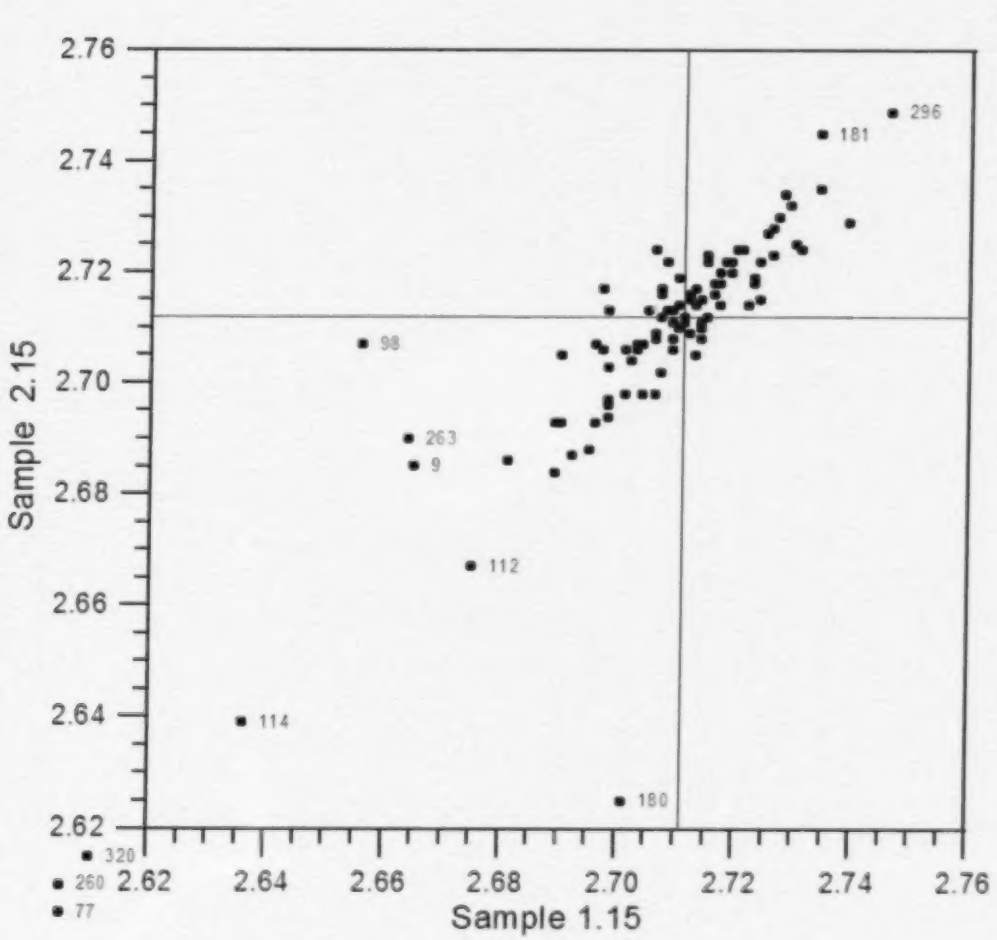
Test 25: Percent Passing the 75 um Sieve

	Mat 1	Mat 2
Mean	6.739	6.780
Median	6.755	6.790
Std Dev	0.438	0.511

n = 213

Labs Eliminated: 17; 26; 34; 77; 83; 93; 156; 168; 232; 266; 287; 305; 342

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



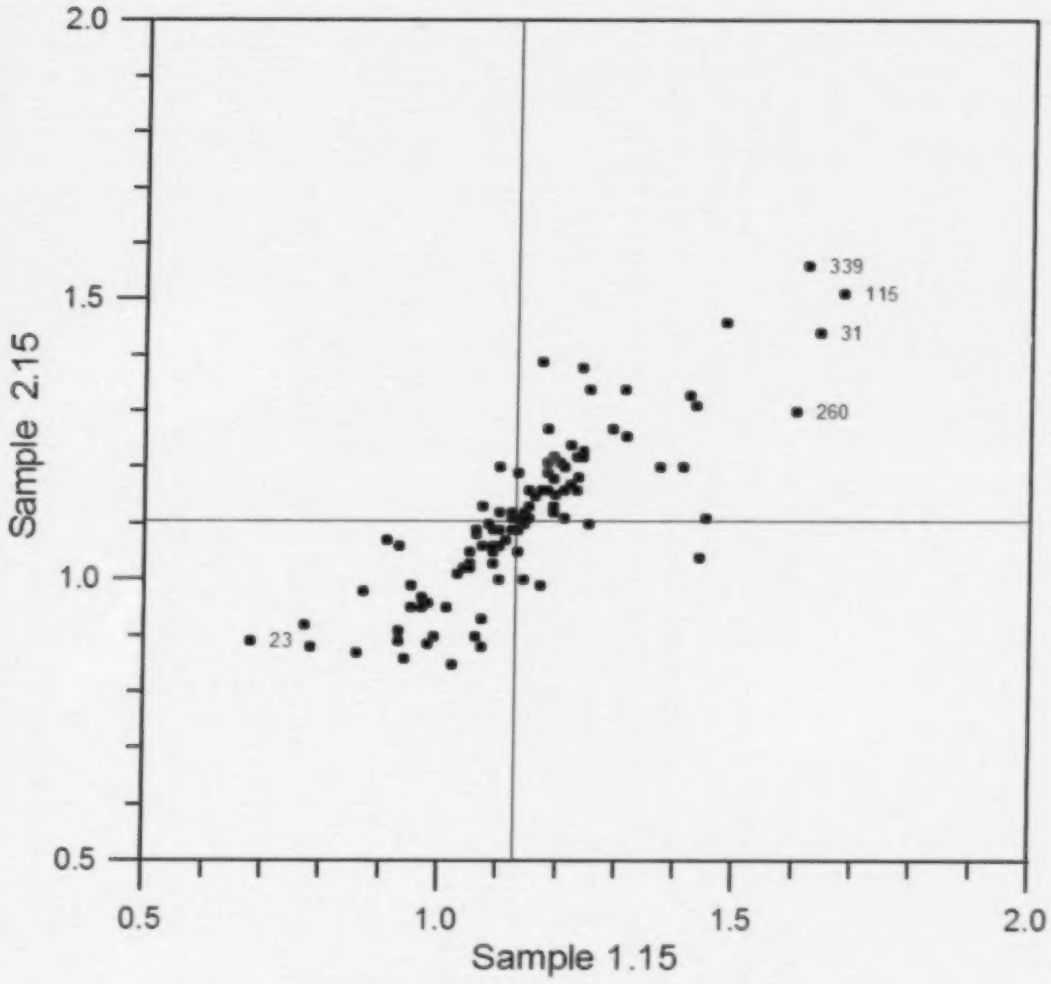
Test 27: Relative Density of Fine Aggregate (O. D)

	Mat 1	Mat 2
Mean	2.711	2.712
Median	2.710	2.709
Std Dev	0.012	0.012

n = 86

Labs Eliminated: 9; 77; 98; 112; 114; 172; 180; 181; 260; 263; 296; 320

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



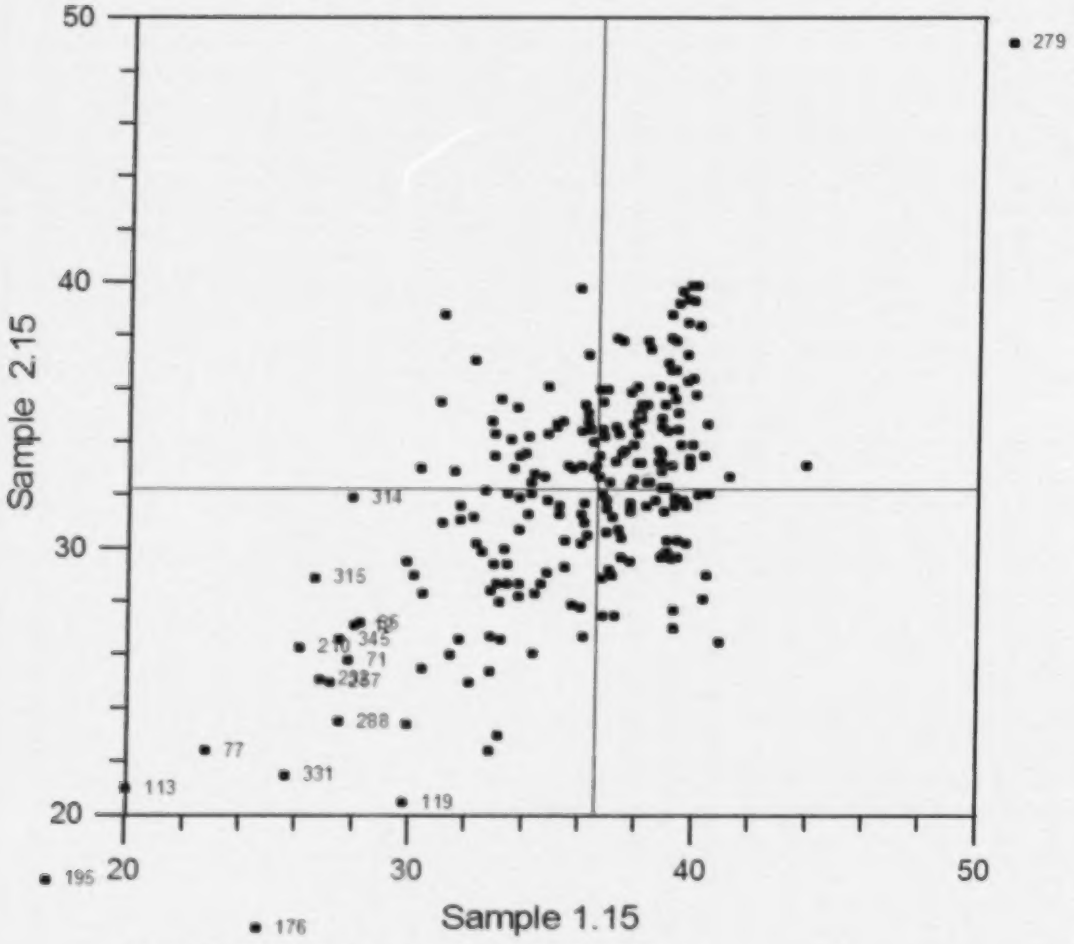
Test 28: Absorption of Fine Aggregate

	Mat 1	Mat 2
Mean	1.129	1.105
Median	1.125	1.155
Std Dev	0.139	0.136

n = 93

Labs Eliminated: 23; 31; 115; 260; 339

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



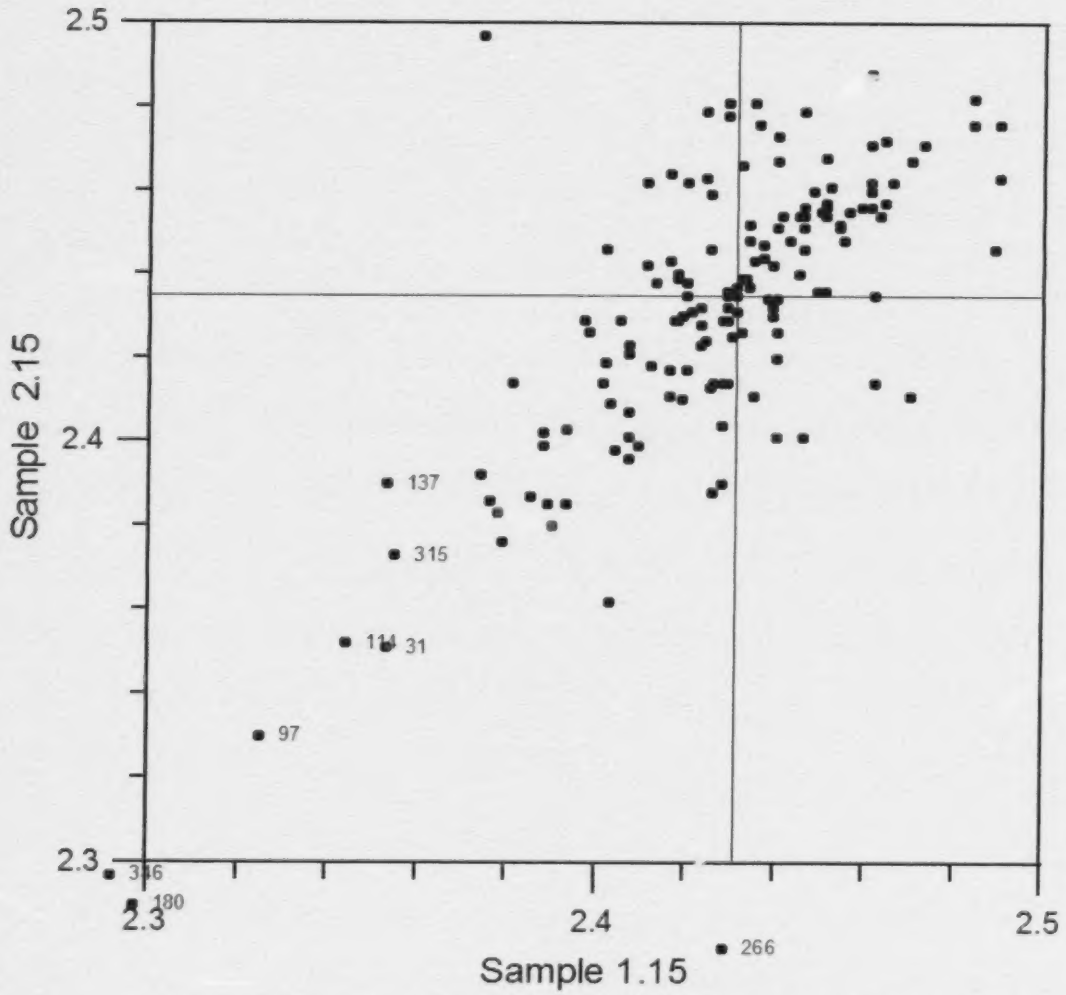
Test 30: Percent Asphalt Coated Particles

	Mat 1	Mat 2
Mean	36.559	32.251
Median	36.860	31.150
Std Dev	2.8071	3.6541

n = 209

Labs Eliminated: 12; 65; 71; 77; 113; 119; 176; 195; 210; 232; 257; 279; 288; 314; 315; 331; 345

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



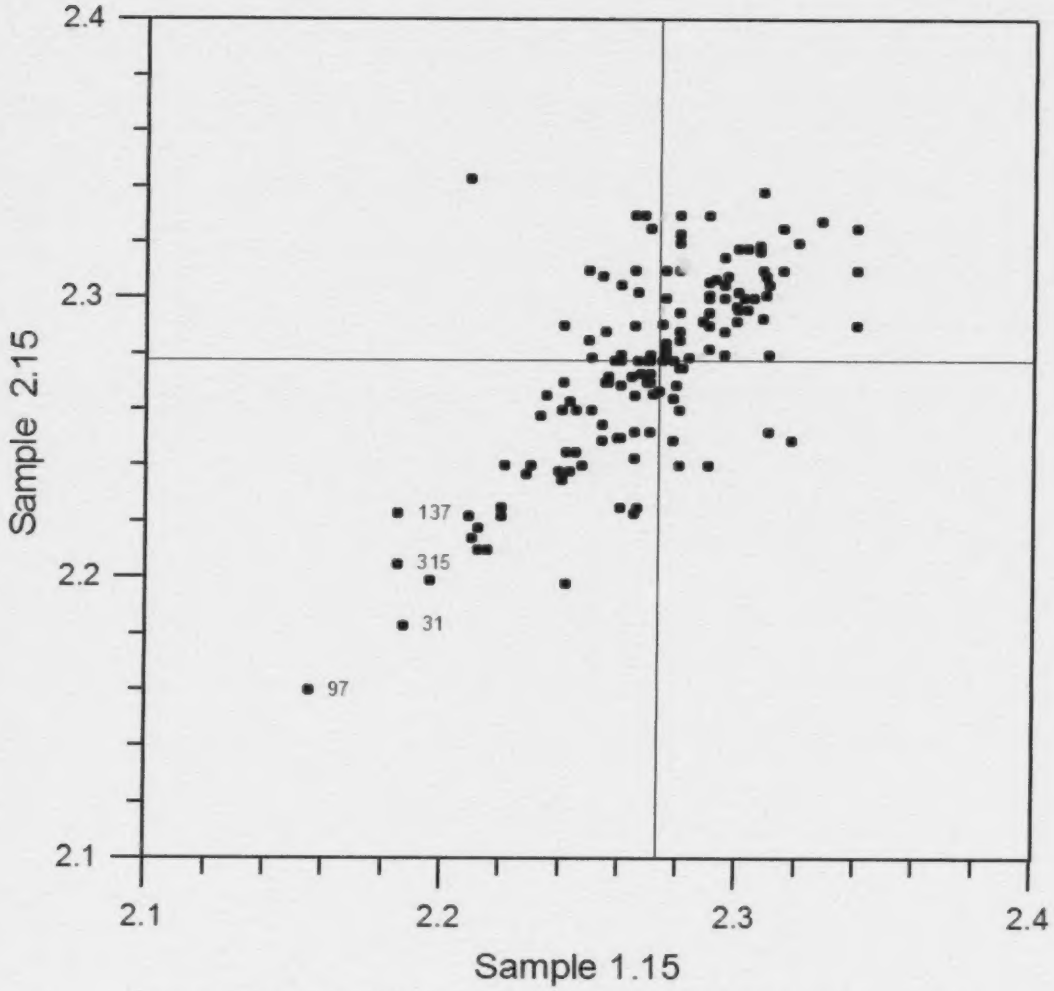
Test 31: Maximum Wet Density g/cm3 (Moisture-Density)

	Mat 1	Mat 2
Mean	2.431	2.435
Median	2.432	2.430
Std Dev	0.024	0.027

n = 147

Labs Eliminated: 31; 97; 114; 137; 180; 266; 315; 346

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



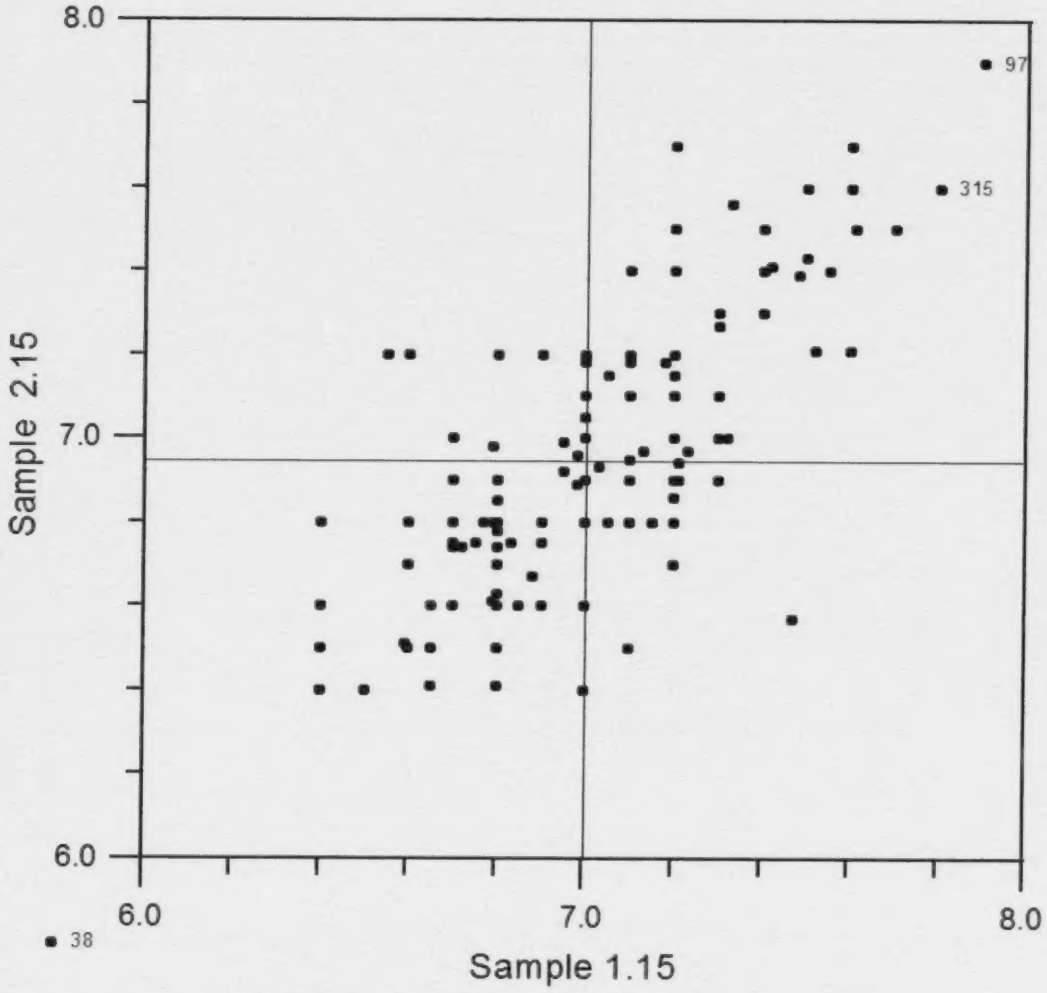
Test 32: Maximum Dry Density g/cm3 (Moisture-Density)

	Mat 1	Mat 2
Mean	2.273	2.278
Median	2.268	2.270
Std Dev	0.028	0.032

n = 151

Labs Eliminated: 31; 97; 137; 315

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



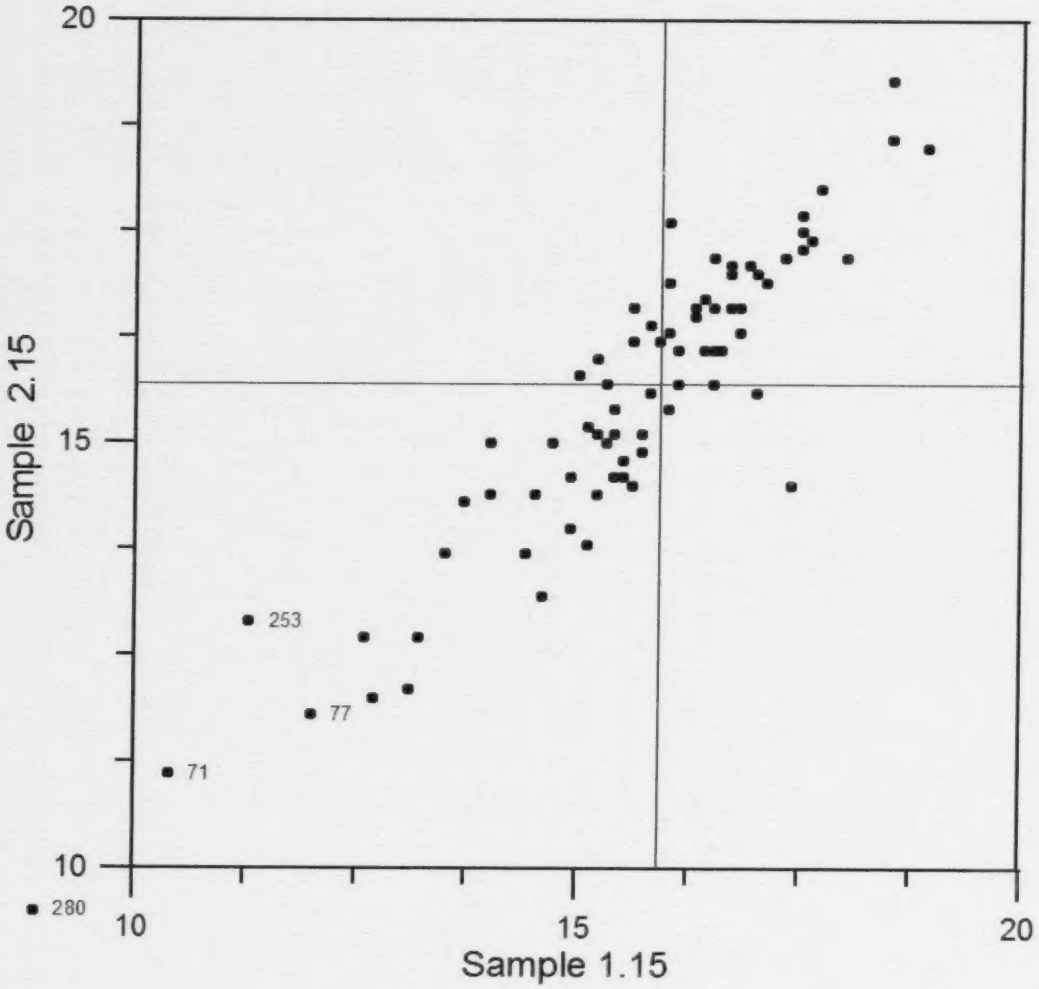
Test 33: Optimum Moisture, % (Moisture - Density)

	Mat 1	Mat 2
Mean	7.002	6.944
Median	7.050	7.050
Std Dev	0.273	0.295

n = 152

Labs Eliminated: 38; 97; 315

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



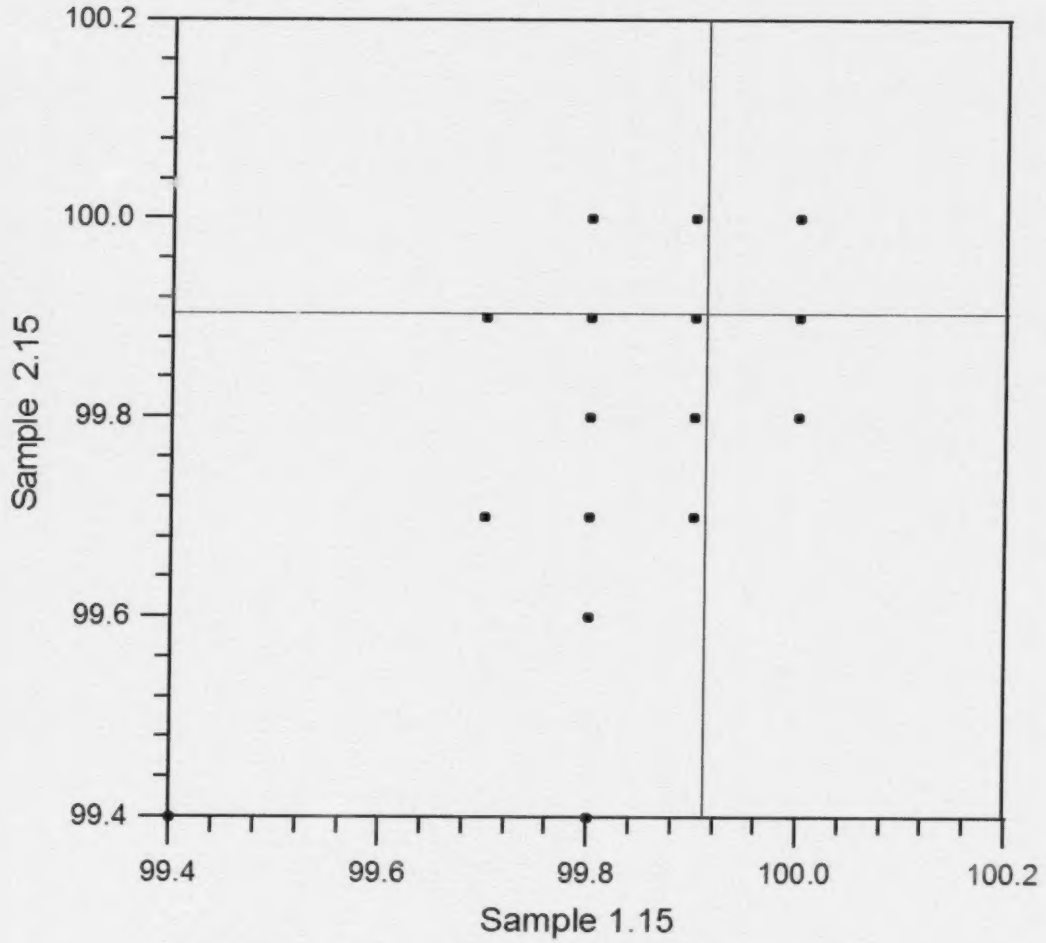
Test 34: Micro-Deval Abrasion Loss (FA), %

	Mat 1	Mat 2
Mean	15.909	15.705
Median	15.750	15.650
Std Dev	1.3217	1.5805

n = 74

Labs Eliminated: 71; 77; 253; 280

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



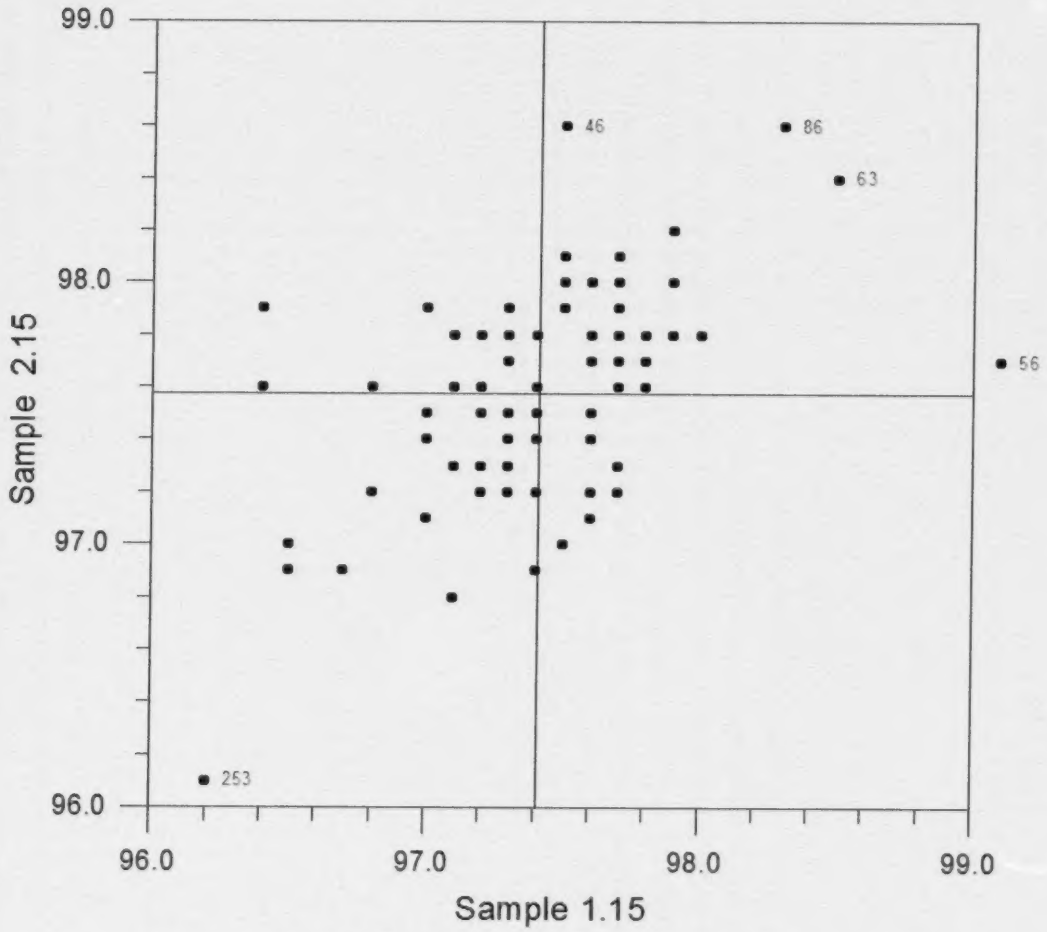
Test 40: Percent Passing the 2.00 mm Sieve (Soil)

	Mat 1	Mat 2
Mean	99.886	99.871
Median	99.000	98.950
Std Dev	0.2253	0.2479

n = 85

Labs Eliminated: None

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



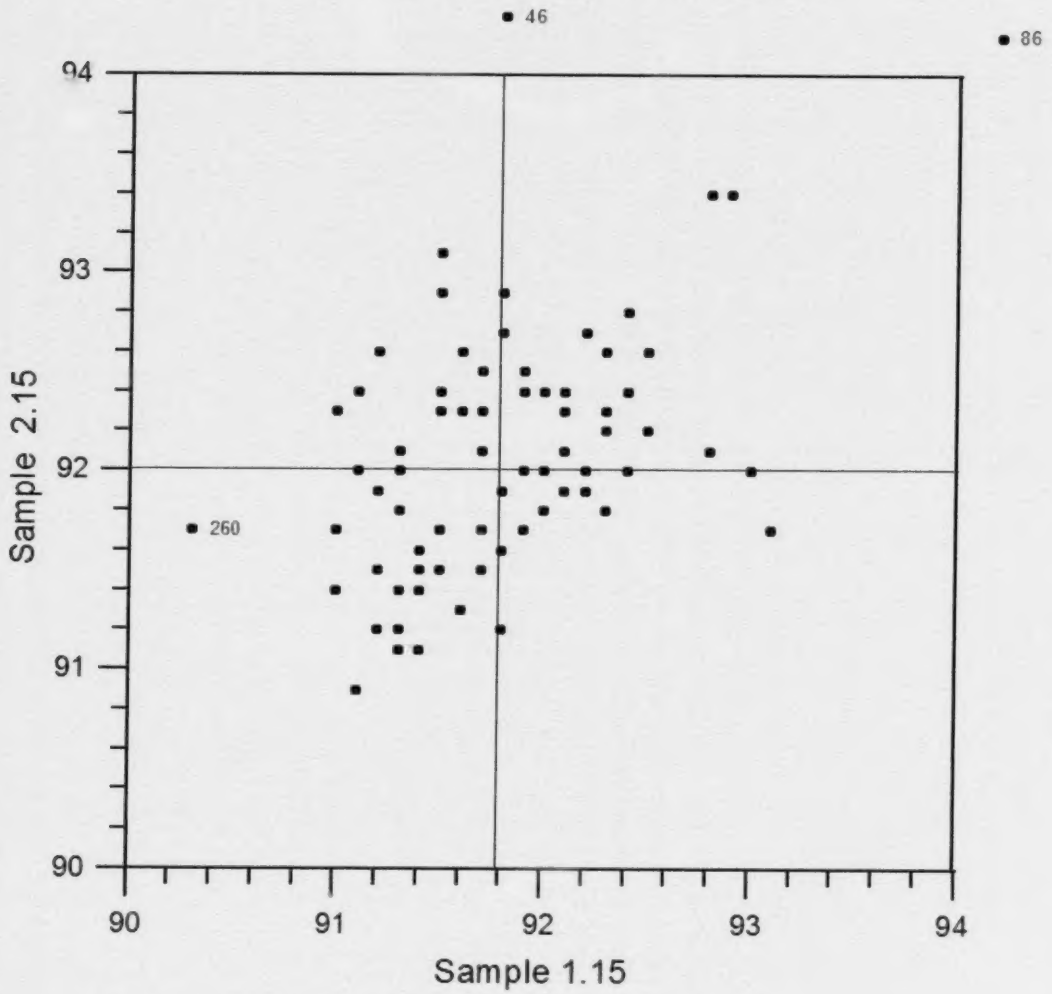
Test 41: Percent Passing the 425 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	97.376	97.574
Median	97.350	97.500
Std Dev	0.3643	0.3250

n = 80

Labs Eliminated: 46; 56; 63; 86; 253

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



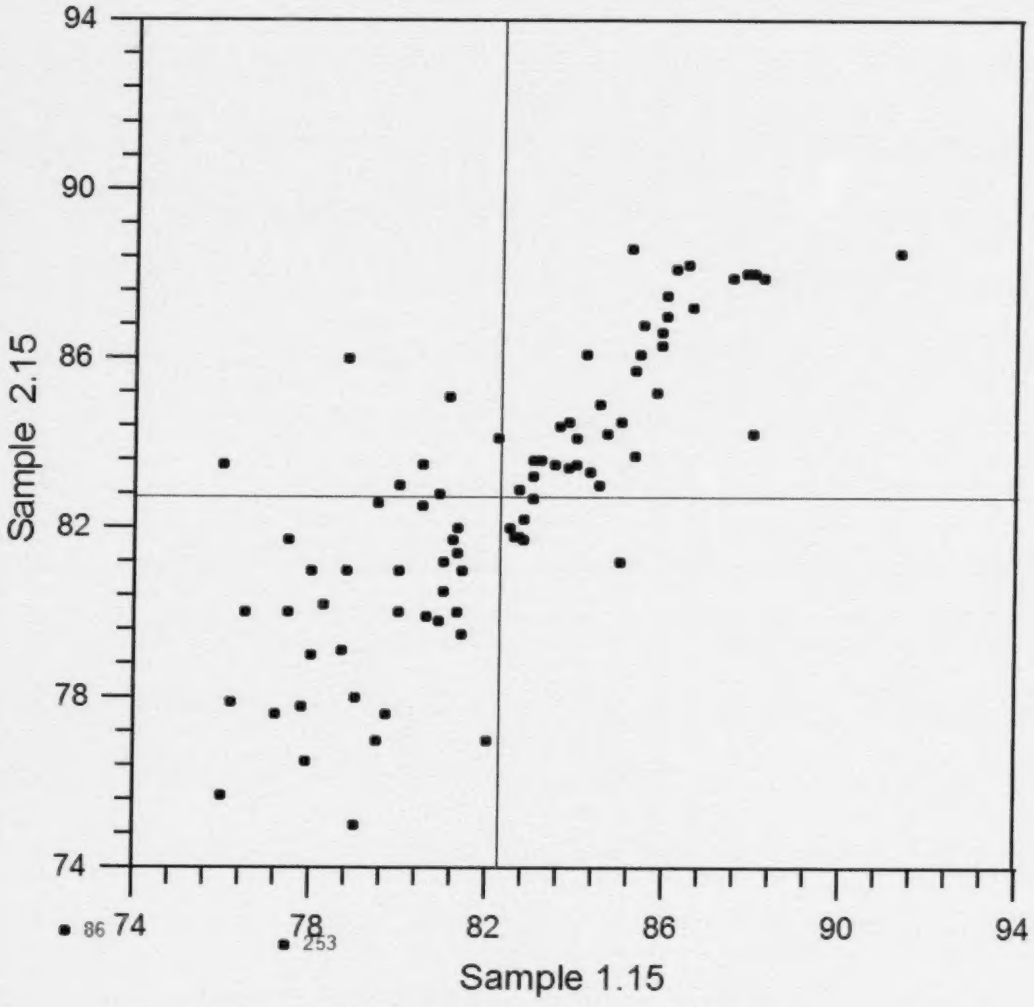
Test 42: Percent Passing the 75 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	91.786	92.011
Median	92.050	92.150
Std Dev	0.4884	0.5184

n = 82

Labs Eliminated: 46; 86; 260

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



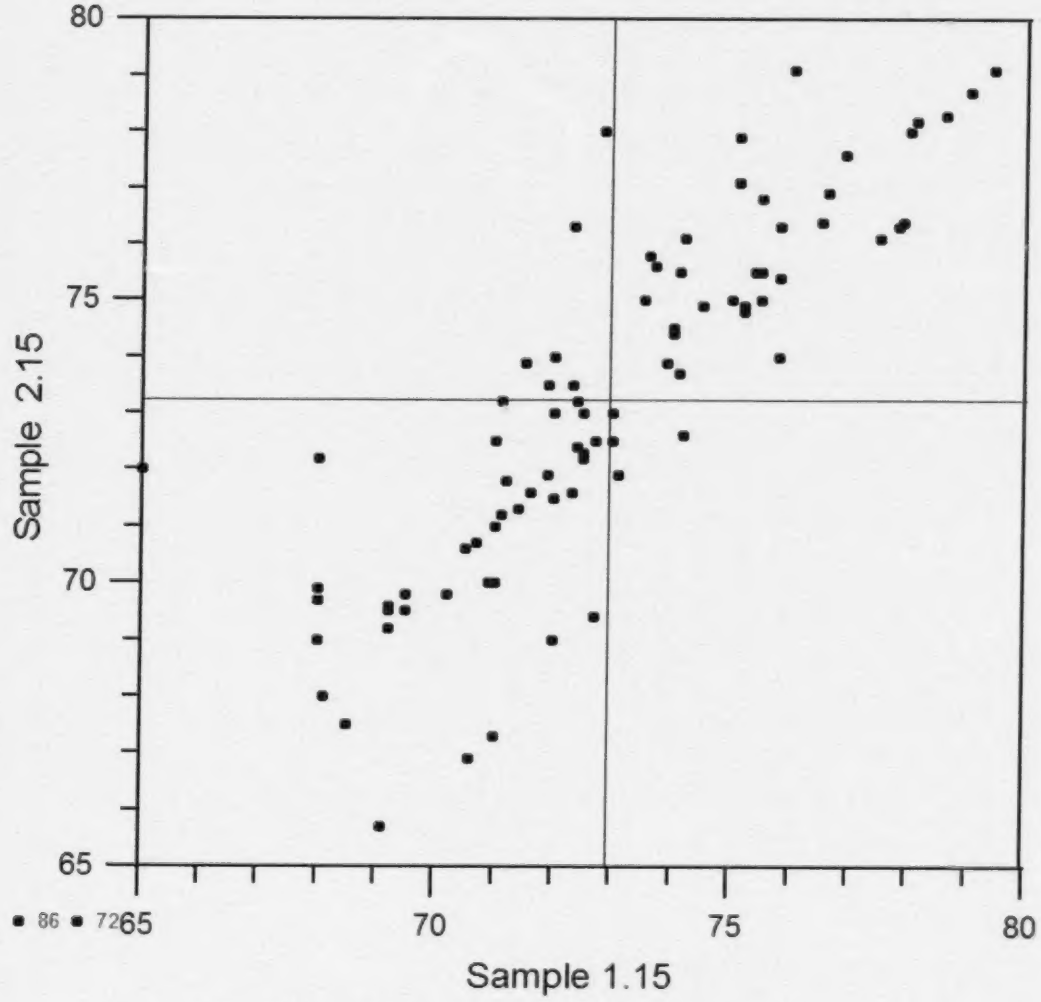
Test 43: Percent Passing the 20 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	82.269	82.708
Median	83.650	81.800
Std Dev	3.3285	3.2842

n = 83

Labs Eliminated: 86; 253

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



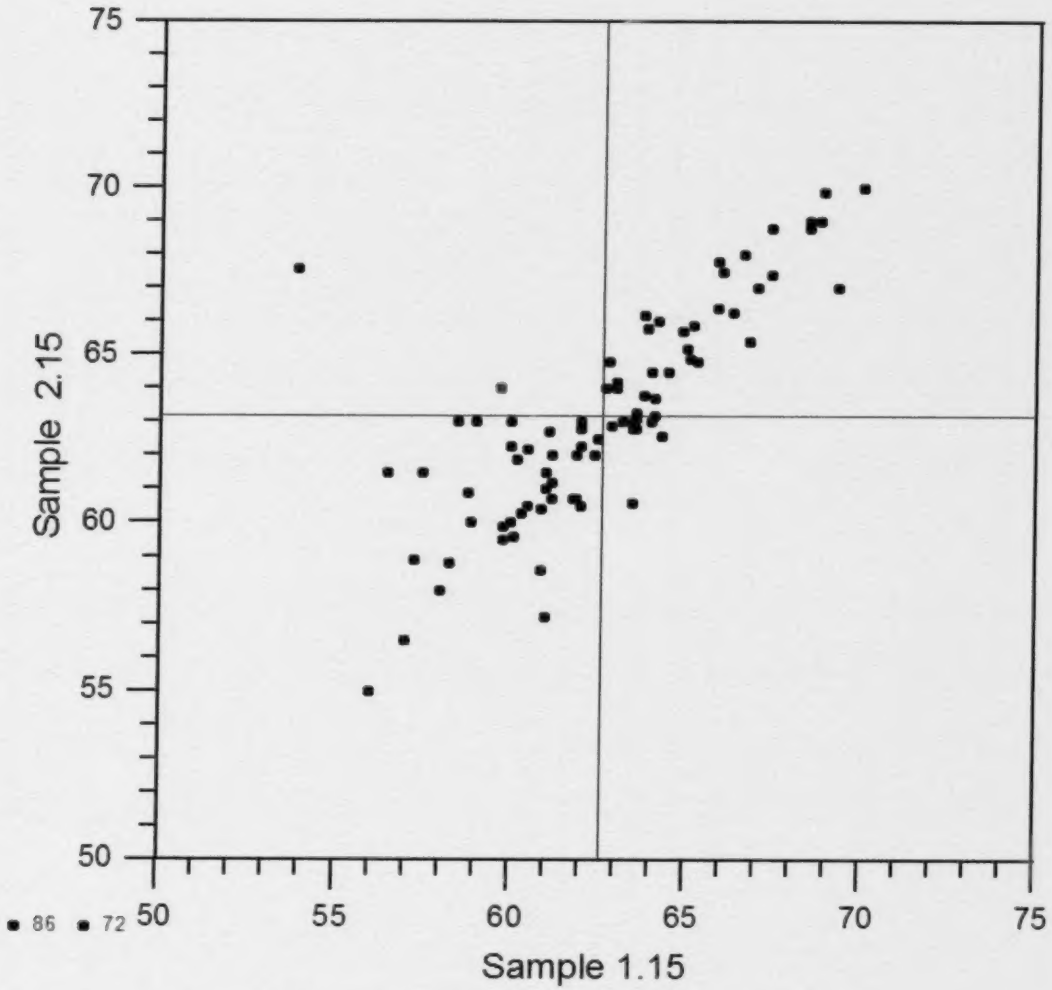
Test 44: Percent Passing the 5 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	72.933	73.246
Median	72.200	72.400
Std Dev	2.9659	3.1469

n = 83

Labs Eliminated: 72; 86

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



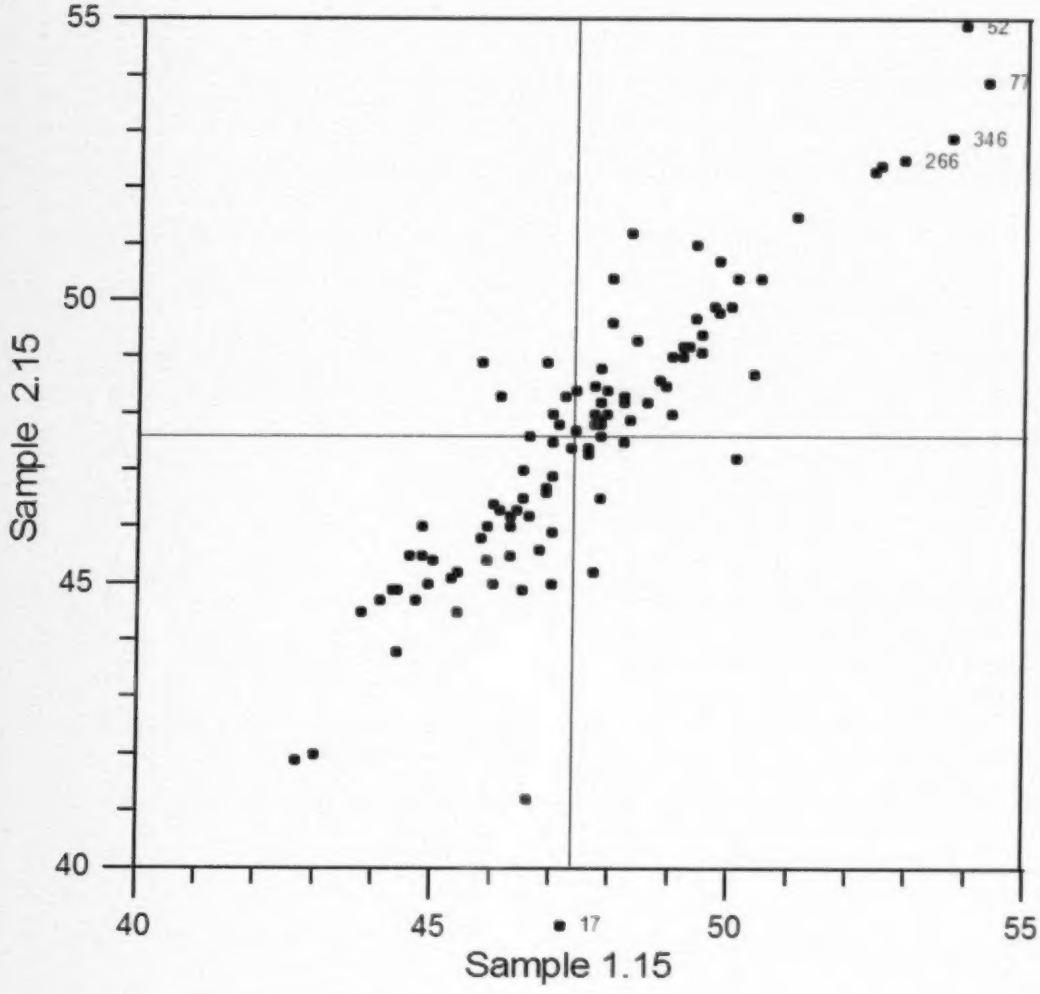
Test 45: Percent Passing the 2 μm Sieve (Soil)

	Mat 1	Mat 2
Mean	62.614	63.208
Median	61.950	62.500
Std Dev	3.2904	3.1476

n = 83

Labs Eliminated: 72; 86

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



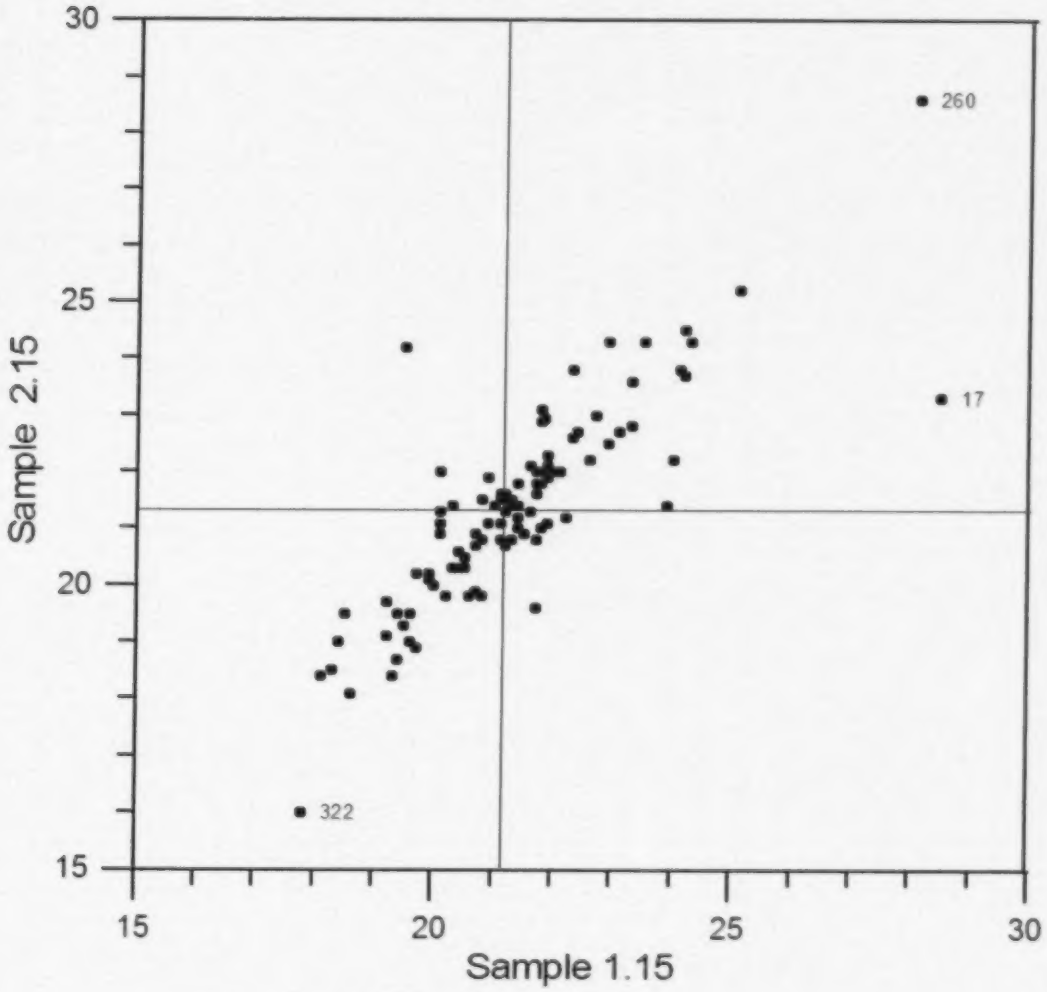
Test 46: Liquid Limit, %

	Mat 1	Mat 2
Mean	47.371	47.607
Median	47.600	46.800
Std Dev	1.9190	2.3471

n = 97

Labs Eliminated: 17; 52; 77; 266; 346

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



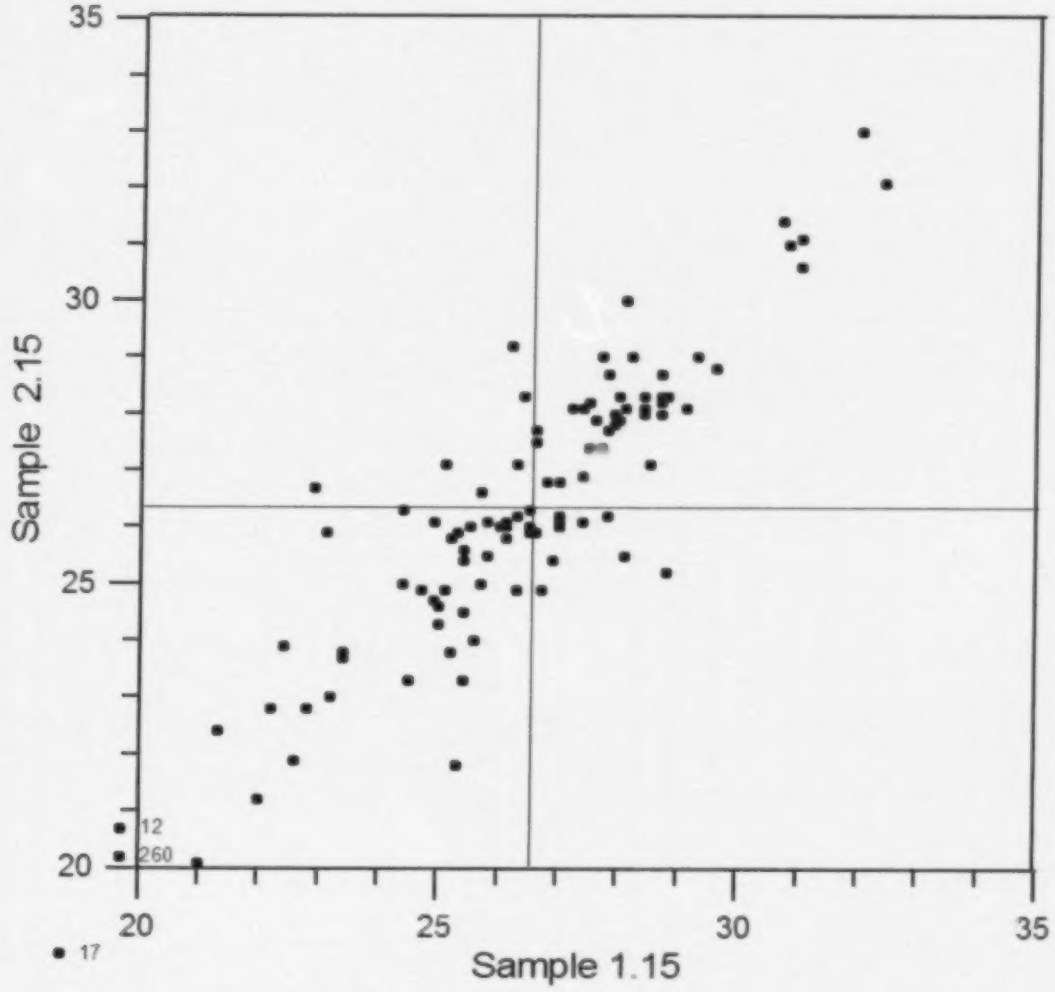
Test 47: Plastic Limit, %

	Mat 1	Mat 2
Mean	21.153	21.313
Median	21.600	21.650
Std Dev	1.4885	1.5070

n = 99

Labs Eliminated: 17; 260; 322

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



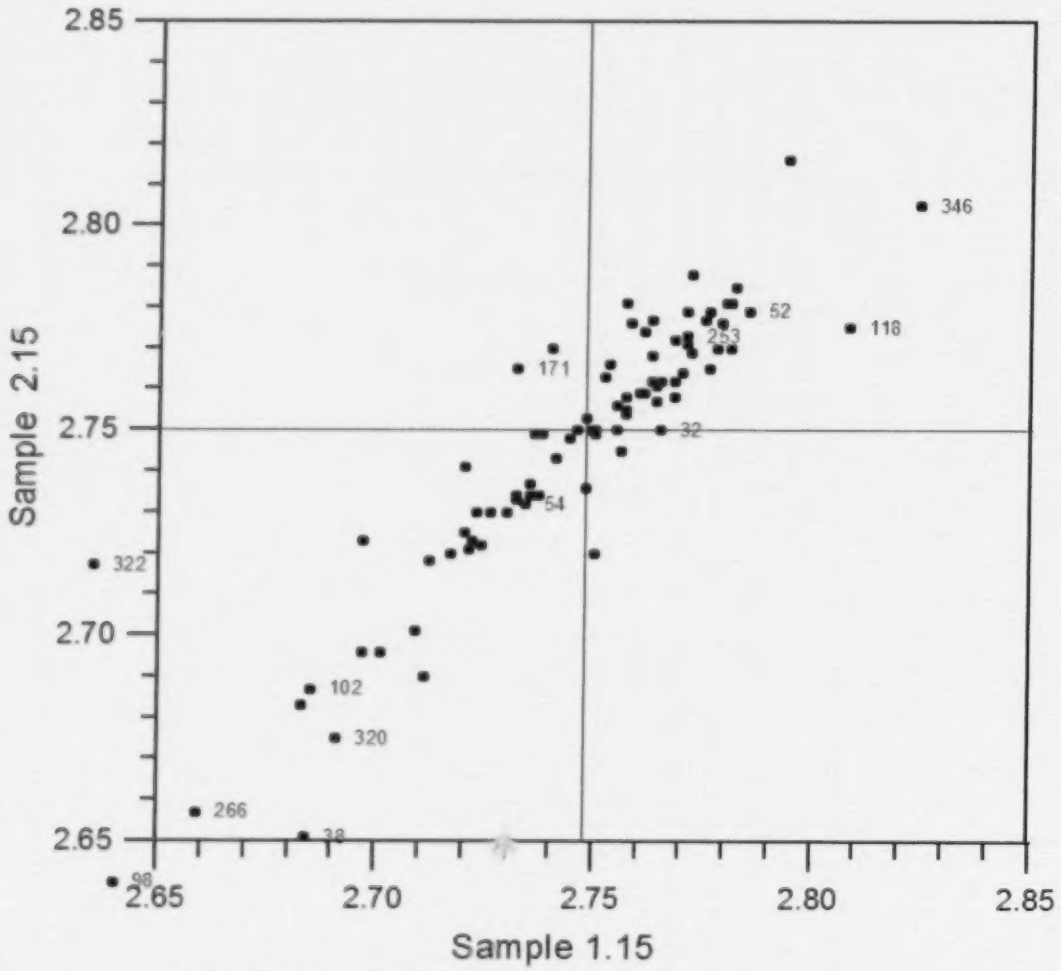
Test 48: Plasticity Index, %

	Mat 1	Mat 2
Mean	26.549	26.370
Median	26.700	26.550
Std Dev	2.2298	2.4541

n = 99

Labs Eliminated: 12; 17; 260

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



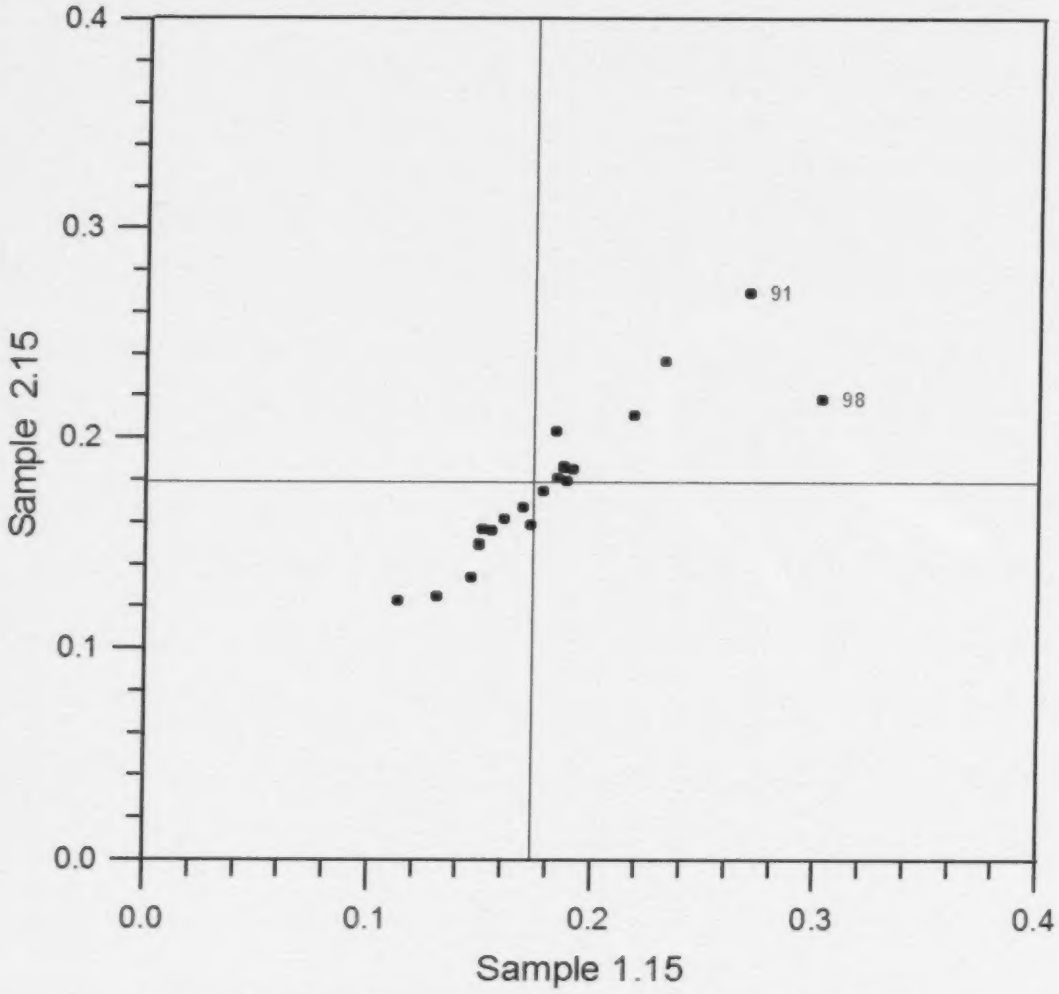
Test 49: Specific Gravity of Soil

	Mat 1	Mat 2
Mean	2.747	2.751
Median	2.739	2.750
Std Dev	0.026	0.026

n = 72

Labs Eliminated: 32; 38; 52; 54; 98; 102; 118; 171; 253; 266; 320; 322; 346

2015 MTO AGGREGATE AND SOIL PROFICIENCY SAMPLE TESTING PROGRAM



Test 123: Accelerated Mortar Bar - 14 Days in NaOH

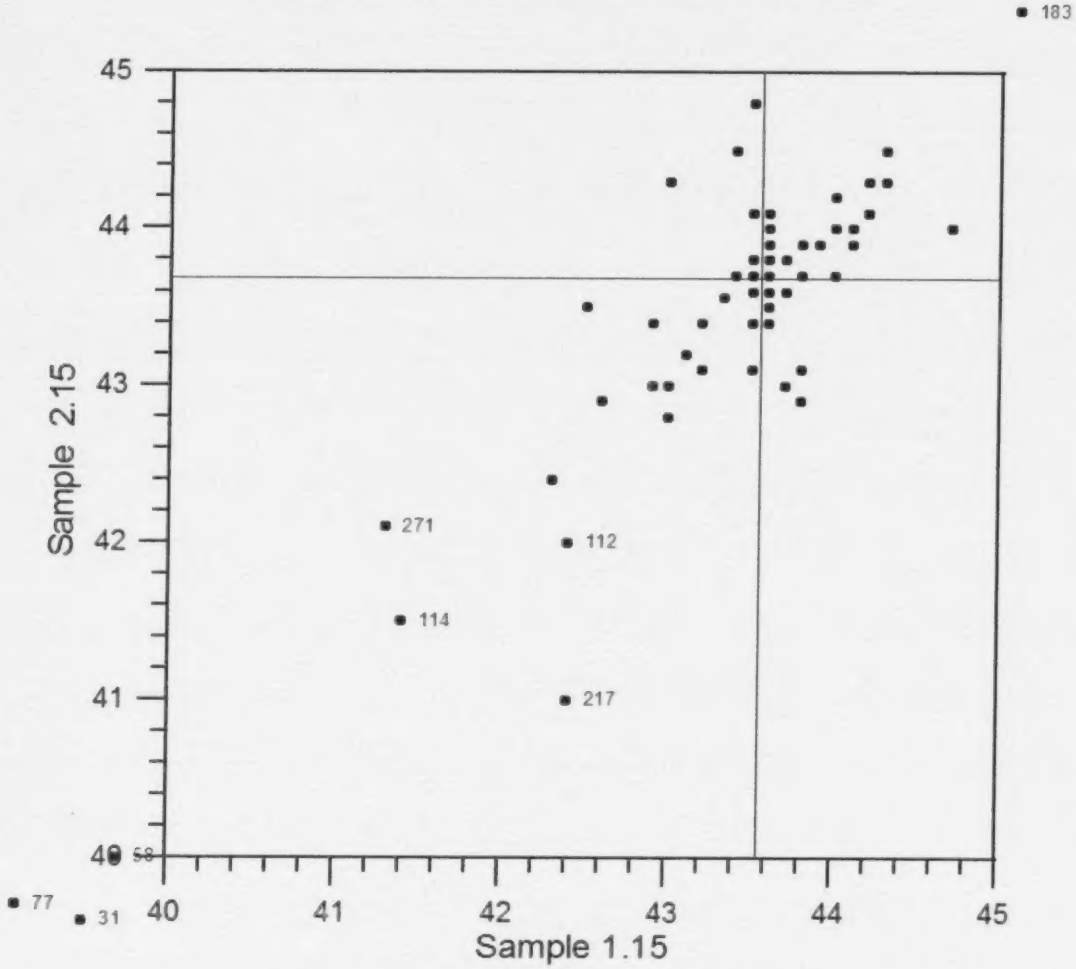
	Mat 1	Mat 2
Mean	0.173	0.179
Median	0.172	0.180
Std Dev	0.030	0.036

n = 20

Labs Eliminated: 91; 98

Appendix D2: Scatter Diagrams

2015 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM



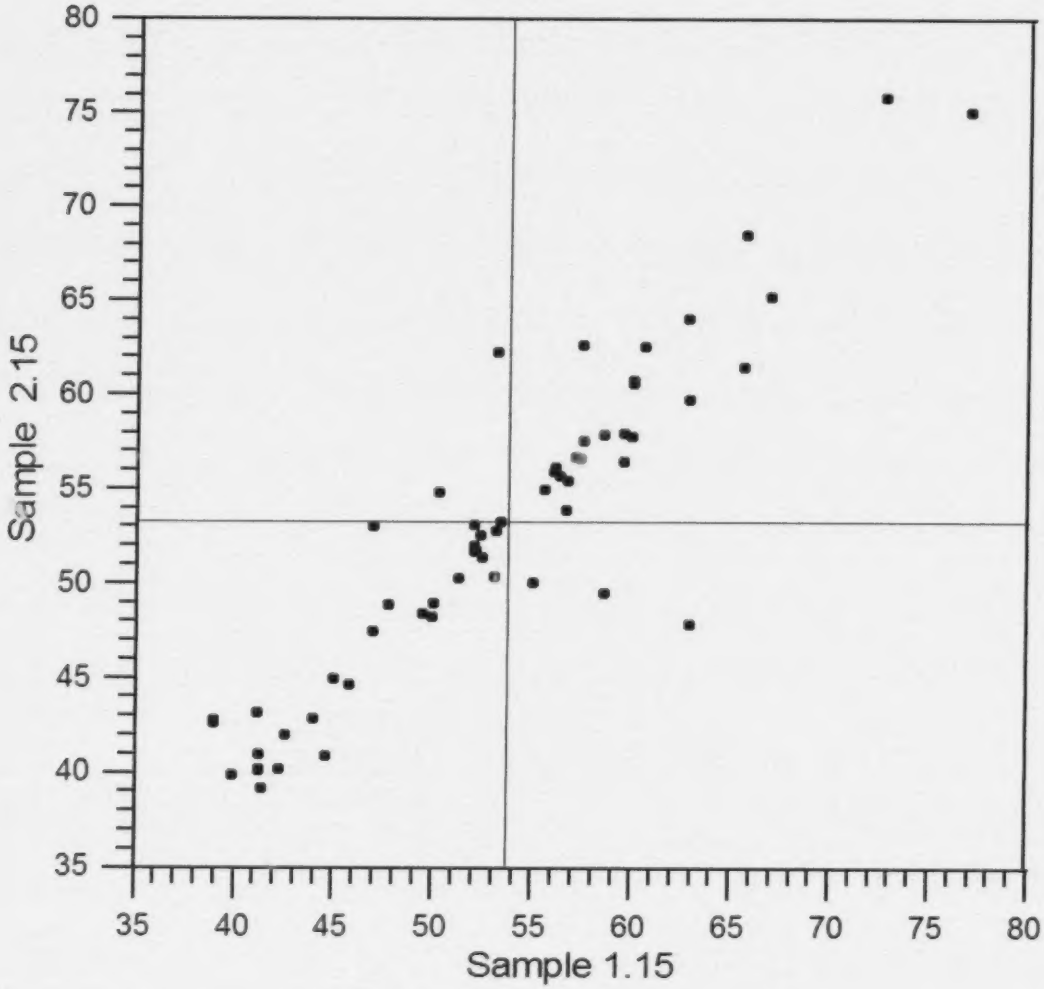
Test 95: Uncompacted Void Content of Fine Aggregate

	Mat 1	Mat 2
Mean	43.557	43.681
Median	43.500	43.600
Std Dev	0.5165	0.4860

n = 56

Labs Eliminated: 31; 58; 77; 112; 114; 183; 217; 271

2015 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM



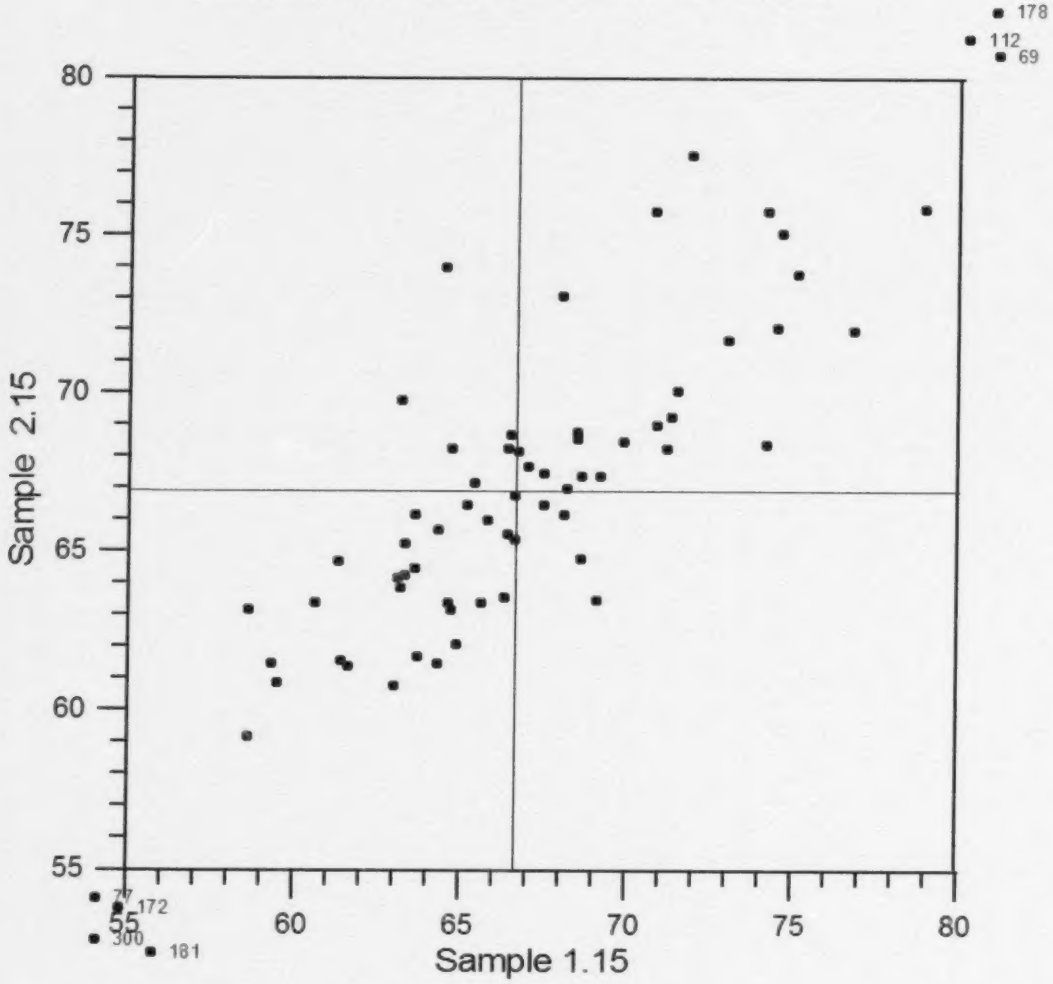
Test 96: Sand Equivalent Value of Fine Aggregate

	Mat 1	Mat 2
Mean	53.719	53.289
Median	57.900	57.550
Std Dev	8.6485	8.6810

n = 62

Labs Eliminated: None

2015 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM



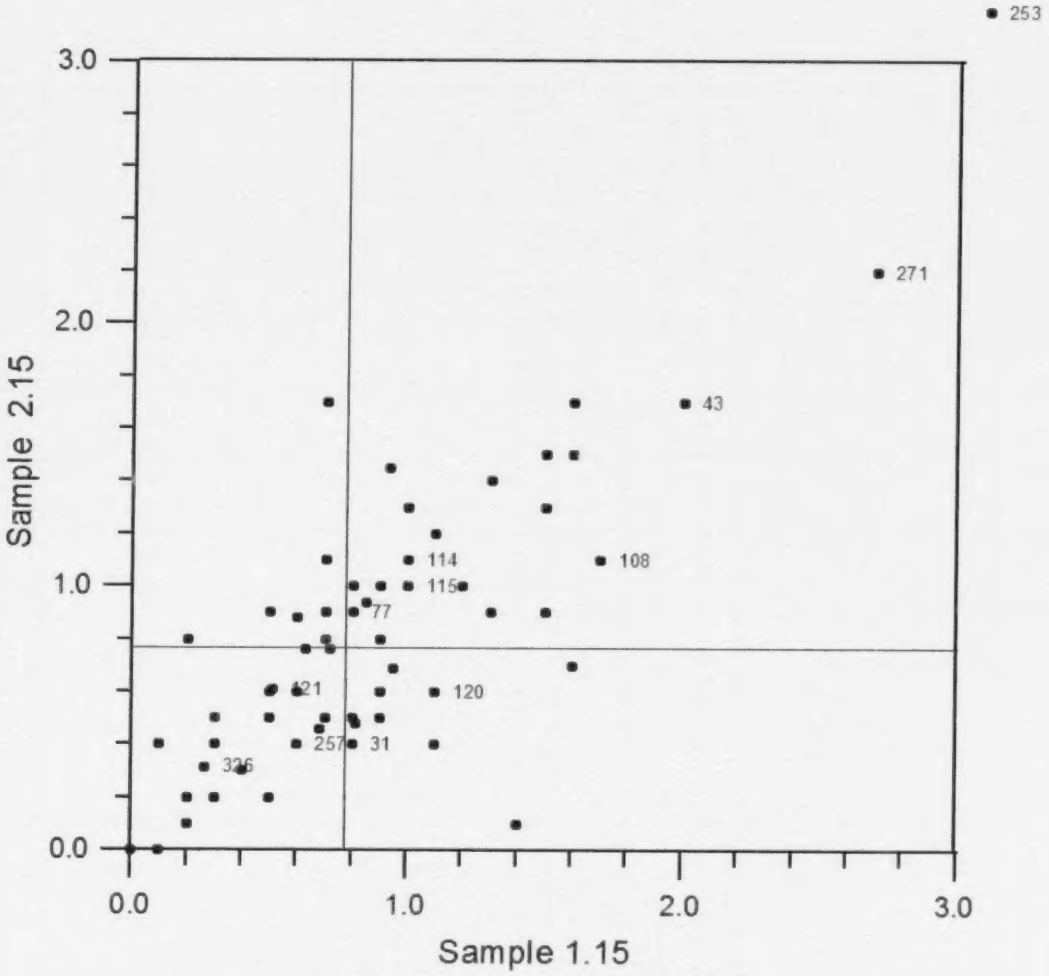
Test 97: Percent Fractured Particles

	Mat 1	Mat 2
Mean	66.653	66.944
Median	68.750	68.400
Std Dev	4.7240	4.3137

n = 63

Labs Eliminated: 69; 77; 112; 172; 178; 181; 300

2015 MTO SUPERPAVE
CONSENSUS PROPERTY TESTING PROGRAM



Test 99: Percent Flat and Elongated Particles

	Mat 1	Mat 2
Mean	0.774	0.765
Median	0.800	0.850
Std Dev	0.416	0.433

n = 58

Labs Eliminated: 31; 43; 77; 108; 114; 115; 120; 121; 253; 257; 271; 326

Appendix E1: Petrographic Results of Coarse Aggregate

Laboratory Number		1				1				5				5			
Sample Number		1.15				2.15				1.15				2.15			
Rock Type/Fraction		R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %
Carbonate (hard, silty, hard)	1	8.2	10.2	14.8	11.1	7.5	12.2	19.3	13.0	4.7	5.4	12.9	7.6	7.1	7.8	17.9	11.1
Carbonate (surf. Weath.; silty, surf. Weath.; med. Hard, silty, med. Hard)	20	0.2	4.4	3.3	2.6	3.1	2.3	4.7	3.4	12.1	9.9	7.1	9.7	5.4	5.6	5.7	5.6
Carbonate (sandy, hard or medium hard)	2									0.9	0.7	0.1	0.6	1.1			0.4
Carbonate (slightly cherty, <5%)	21	0.3			0.1							1.0	0.4				
Marble (hard or medium hard)	23																
Conglomerate-Sandstone-Arkose (hard)	3	3.2	2.5		1.9	3.6	1.8	2.5	2.7	0.6	3.1	2.5	2.0	1.0	5.3	2.4	2.8
Conglomerate-Sandstone-Arkose (medium har	22					0.5		1.6	0.7	1.4	0.8	0.2	0.8	0.7	1.0	1.5	1.0
Greywacke - Argillite (hard or medium hard)	6	6.4	15.0	12.3	11.1	9.3	11.5	4.6	8.3	20.3	22.4	28.4	23.8	24.9	23.3	29.6	26.0
Gneiss - Amphibolite - Schist (hard)	4	21.9	15.4	12.8	16.8	21.6	17.3	11.9	16.9	23.4	24.9	17.5	21.8	38.1	34.3	22.8	31.6
Quartzite	5	1.0	4.5	3.4	2.9	1.8	3.0	3.0	2.6								
Granite - Diorite - Gabbro (hard)	8	26.5	20.6	24.2	23.9	20.9	23.6	15.2	19.7	27.3	25.1	18.6	23.6	13.2	10.9	9.7	11.3
Volcanic (hard or medium hard)	7	25.8	17.6	23.1	22.4	28.6	24.7	30.2	28.0			2.1	0.7	4.0	2.7	1.1	2.6
Trap (≤20% sulphide)	9									2.1	2.7	2.8	2.5				
Quartz (vein or pegmatitic)	10	2.5	7.7	2.8	4.2	0.5	0.6	2.8	1.3		0.5	0.1	0.2			0.8	0.3
Feldspar	11																
Iron Formation	71															0.3	0.1
Red Jasper - Flint	81													1.0			0.4
Orthoquartzite																	
Metasedimentary (hard)																	
Metavolcanic (hard)																	
Total Good Aggregate (%)		**96.0**	**97.9**	**96.7**	**96.8**	**97.5**	**97.2**	**95.8**	**96.8**	**92.8**	**95.5**	**92.8**	**93.7**	**96.5**	**90.9**	**91.8**	**93.2**
Carbonate (soft, silty, soft, slightly shaley)	35									1.2	1.2	1.9	1.5	0.8	2.2	0.3	1.0
Carbonate (soft, pitted)	41	1.2			0.4												
Carbonate (deeply weathered, silty, deeply wea	42	0.4	0.8		0.4												
Carbonate (sandy, soft)	40																
Chert-Cherty Carbonate (<20% leached chert)	26	0.4			0.1					1.2	0.9	1.5	1.2	1.5	3.4	2.5	2.4
Conglomerate-Sandstone-Arkose (brittle)	30	0.3			0.1		0.4		0.1								
Greywacke (brittle)	29						0.4	2.8	1.1	0.7		0.3	0.4			0.4	0.2
Encrustation	52	1.5	0.7	0.3	0.8	0.8	0.2		0.3			0.3	0.1				
Gneiss - Amphibolite - Schist (brittle)	25			2.0	0.7					2.4	0.5	1.1	1.3	1.2	2.1	5.0	2.8
Argillite (medium soft)	34							0.1									
Granite - Diorite - Gabbro (brittle)	27							0.4	0.1	1.1	0.9	1.2	1.1				
Volcanic (soft)	28																
Iron Formation	82																
Total Fair Aggregate (%)		**3.8**	**1.5**	**2.3**	**2.6**	**0.8**	**0.9**	**3.3**	**1.1**	**6.6**	**3.5**	**6.3**	**5.6**	**3.5**	**7.1**	**8.2**	**6.4**
Carbonate (shaley, clayey, silty, clayey)	43	0.2			0.1												
Carbonate (ochreous, sandy, ochreous)	44			1.0	0.3	1.0			0.4								
Chert-Cherty Carbonate (>20% leached chert)	45		0.3		0.1	0.4	1.0		0.5	0.2	0.6	0.8	0.5		1.4		0.4
Conglomerate-Sandstone-Arkose (friable)	46					0.3			0.1								
Siltstone	56																
Cementation (partial)	53																
Gneiss-Amphibolite (friable)	50		0.3		0.1					0.4			0.1				
Schist (soft)	55																
Granite-Diorite-Gabbro (friable)	51										0.4	0.1	0.1				
Volcanic (very soft, porous)	48																
IRON FORMATION (highly weathered)	84																
Total poor Aggregate (%)		0.2	0.6	**1.0**	**0.6**	**1.8**	**1.0**		**0.9**	**0.6**	**1.0**	**0.9**	**0.7**		**1.4**		**0.4**
Ochre	60						0.5		0.2								
Shale	61																
Clay	62						0.4		0.1								
Volcanic-Gneiss-Schist (decomposed)	63							0.9	0.3								
Carbonate (very weak, deeply weathered)	64																
Total Deleterious Aggregate (%)							**0.9**	**0.9**	**0.6**								
Reported Total Mass Examined (g)		**1532.4**	**526.1**	**217.9**		**1531.7**	**528.4**	**211.8**		**1523.2**	**527.4**	**209.7**		**1537.4**	**525.6**	**216.9**	
% GOOD	X 1 =	96.0	97.9	96.7		97.5	97.2	95.8		92.8	95.5	92.8		96.5	90.9	91.8	
% FAIR	X 3 =	11.4	4.6	6.9		2.3	2.8	9.9		19.5	10.5	18.9		10.5	23.1	24.6	
% POOR	X 6 =	1.3	3.6	5.8		10.6	6.1			3.6	6.0	5.4			8.4		
% DELETERIOUS	X 10 =						9.9										
PETROGRAPHIC NUMBER		109.7	106.1	109.4		110.3	115.0	114.7		115.9	112.0	117.1		107.0	122.4	116.4	
WTD. AVG. PETROGRAPHIC NUMBER		**108.2**				**113.3**				**114.7**				**114.0**			

Laboratory Number		13				13				14				14			
Sample Number		1.15				2.15				1.15				2.15			
Rock Type/Fraction		R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %
Carbonate (hard, silty, hard)	1	10.1	27.3	23.7	20.0	10.3	9.3	34.6	18.5	7.3	10.5	20.2	12.8	8.8	12.7	17.0	12.8
Carbonate (surf. Weath., silty, surf. Weath., med. Hard, silty, med. Hard)	20	0.9	2.4		1.0	3.4	4.0	2.0	3.1	2.7	1.7	1.3	1.8	3.1	4.7	4.1	3.9
Carbonate (sandy, hard or medium hard)	2											0.1	0.1		0.7		0.2
Carbonate (slightly cherty <5%)	21						0.4		0.1	1.1	1.2	2.7	1.7	0.8	0.6	1.1	0.9
Marble (hard or medium hard)	23		0.3		0.1		1.0		0.3								
Conglomerate-Sandstone-Arkose (hard)	3		1.1	0.3	0.4					0.3	1.4	1.1	0.9	0.5	0.4	1.0	0.6
Conglomerate-Sandstone-Arkose (medium har	22																
Greywacke - Argillite (hard or medium hard)	6	35.5	16.3	26.9	26.7	28.6	22.2	15.4	22.1	38.8	20.8	33.7	31.6	32.6	26.5	29.3	29.6
Gneiss - Amphibolite - Schist (hard)	4	0.5	9.9	1.2	3.6	7.3	2.8	1.0	3.8	21.9	26.7	14.5	20.8	33.3	26.4	15.3	24.9
Quartzite	5	7.7	5.7	7.1	6.9	4.0	8.4	5.4	5.8	2.6	3.8	3.3	3.2	2.6	2.0	2.0	2.2
Granite - Diorite - Gabbro (hard)	8	37.9	33.4	30.3	33.9	45.3	38.6	33.8	39.3	18.6	24.8	15.7	19.4	10.1	17.5	18.7	15.4
Volcanic (hard or medium hard)	7									1.3	3.9	2.0	2.3	5.4	4.0	3.5	4.3
Trap (≤20% sulphide)	9			2.7	0.9	0.9			0.3								
Quartz (vein or pegmatitic)	10	6.6	2.0	6.8	5.3		9.5	7.8	5.6								
Feldspar	11																
Iron Formation	71																
Red Jasper - Flint	81																
Orthoquartzite																	
Metasedimentary (hard)																	
Metavolcanic (hard)																	
Total Good Aggregate (%)		**99.1**	**98.5**	**99.2**	**99.0**	**99.8**	**96.1**	**99.9**	**98.7**	**94.6**	**94.8**	**94.6**	**94.6**	**97.2**	**95.5**	**92.0**	**94.8**
Carbonate (soft, silty, soft, slightly shaley)	35			0.5	0.2		2.4		0.7	0.9	1.5	0.1	0.8	0.2	0.4	1.0	0.5
Carbonate (soft, pitted)	41																
Carbonate (deeply weathered, silty, deeply wea	42		1.2		0.3	0.2			0.1	0.3			0.1	1.8	0.5	1.1	1.2
Carbonate (sandy, soft)	40																
Chert-Cherty Carbonate (<20% leached chert)	26	0.6			0.2					1.7	1.6	0.5	1.2	0.6	0.4	0.0	0.3
Conglomerate-Sandstone-Arkose (brittle)	30																
Greywacke (brittle)	29																
Encrustation	52																
Gneiss - Amphibolite - Schist (brittle)	25						0.8		0.2	1.0	1.2	2.2	1.6	0.1	1.6	2.9	1.5
Argillite (medium soft)	34																
Granite - Diorite - Gabbro (brittle)	27	0.3			0.1					1.5	0.9	2.5	1.6	0.1	1.3	2.2	1.2
Volcanic (soft)	28													0.0	0.3	0.5	0.3
Iron Formation	82																
Total Fair Aggregate (%)		**0.9**	**1.2**	**0.5**	**0.8**	**0.2**	**3.2**		**1.0**	**5.4**	**5.2**	**5.3**	**5.3**	**2.8**	**4.5**	**7.7**	**5.0**
Carbonate (shaley, clayey, silty, clayey)	43															0.2	0.1
Carbonate (ochreous, sandy, ochreous)	44						0.6		0.2								
Chert-Cherty Carbonate (>20% leached chert)	45																
Conglomerate-Sandstone-Arkose (friable)	46							0.1	0.0							0.1	0.1
Siltstone	56		0.3		0.1												
Cementation (partial)	53																
Gneiss-Amphibolite (friable)	50											0.1	0.1				
Schist (soft)	55			0.3	0.1												
Granite-Diorite-Gabbro (friable)	51																
Volcanic (very soft, porous)	48																
IRON FORMATION (highly weathered)	84																
Total poor Aggregate (%)			**0.3**	**0.3**	**0.2**		**0.6**	**0.1**	**0.2**			**0.1**	**0.1**			**0.3**	**0.2**
Ochre	60																
Shale	61																
Clay	62																
Volcanic-Gneiss-Schist (decomposed)	63																
Carbonate (very weak, deeply weathered)	64																
Total Deleterious Aggregate (%)																	
Reported Total Mass Examined (g)		**1510.1**	**527.5**	**214.9**		**1530.2**	**534.0**	**216.1**		**1550.6**	**530.4**	**215.7**		**1480.7**	**532.0**	**221.5**	
% GOOD	X 1 =	99.1	98.5	99.2		99.8	96.1	99.9		94.6	94.8	94.6		97.2	95.5	92.0	
% FAIR	X 3 =	2.8	3.5	1.4		0.6	9.7			16.2	15.6	15.9		8.4	13.5	23.1	
% POOR	X 6 =		1.8	2.0			3.8	0.6				0.6				1.8	
% DELETERIOUS	X 10 =															0.0	
PETROGRAPHIC NUMBER		101.9	103.8	102.6		100.4	109.6	100.5		110.8	110.4	111.1		105.6	109.0	116.9	
WTD. AVG. PETROGRAPHIC NUMBER		**102.7**				**103.2**				**111.1**				**111.0**			

Laboratory Number		15				15				27				27			
Sample Number		1.15				2.15				1.15				2.15			
Rock Type/Fraction		R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %
Carbonate (hard, silty, hard)	1	3.9	4.3	5.4	4.5	3.8	5.6	5.5	4.9	10.2	14.5	17.2	13.9	9.2	11.9	21.0	14.1
Carbonate (surf. Weath., silty, surf. Weath., med. Hard, silty, med. Hard)	20	6.5	7.9	14.2	9.6	7.1	9.7	12.5	9.8	2.0	2.3	2.7	2.4	1.5	2.2	1.7	1.8
Carbonate (sandy, hard or medium hard)	2																
Carbonate (slightly cherty: <5%)	21	0.5	1.5	0.7	0.9	0.3	0.8	1.0	0.7	0.5	0.4	0.7	0.5				
Marble (hard or medium hard)	23																
Conglomerate-Sandstone-Arkose (hard)	3	3.4	3.1	1.5	2.7	3.0	1.8	2.5	2.5	0.3	4.1	3.4	2.5	2.4	2.1	4.2	3.0
Conglomerate-Sandstone-Arkose (medium har	22	0.8	2.2	2.5	1.8	1.5	0.6	1.0	1.1								
Greywacke - Argilite (hard or medium hard)	6	29.6	23.7	27.4	27.1	30.7	23.0	31.4	28.6	23.6	22.5	23.1	23.1	25.3	25.8	27.9	26.4
Gneiss - Amphibolite - Schist (hard)	4	10.3	13.7	8.6	10.8	12.9	12.9	8.6	11.4	31.6	18.6	10.1	20.2	31.1	23.1	16.8	23.7
Quartzite	5									0.5	0.7	0.3	0.5	0.9	0.4	**11.1**	0.8
Granite - Diorite - Gabbro (hard)	8	31.2	27.2	27.6	28.7	28.7	32.8	24.1	28.3	22.9	24.0	28.9	25.3	19.0	20.6	12.5	17.2
Volcanic (hard or medium hard)	7									1.7	2.4	6.2	3.5	5.8	3.7	6.7	5.5
Trap (≤20% sulphide)	9	7.2	7.1	3.5	5.9	3.9	4.5	3.2	3.8					0.4			0.1
Quartz (vein or pegmatitic)	10	0.3	0.8	0.5	0.5	0.5	0.8		0.4							0.6	0.2
Feldspar	11																
Iron Formation	71																
Red Jasper - Flint	81																
Orthoquartzite																	
Metasedimentary (hard)																	
Metavolcanic (hard)																	
Total Good Aggregate (%)		**93.6**	**91.6**	**91.9**	**92.4**	**92.5**	**92.5**	**89.7**	**91.5**	**93.3**	**89.5**	**92.6**	**91.9**	**95.6**	**89.8**	***102.5***	**92.8**
Carbonate (soft, silty, soft, slightly shaley)	35	1.3	1.1	0.9	1.1	1.3	1.0	1.4	1.2								
Carbonate (soft, pitted)	41									1.0	1.0	1.8	1.3	0.4	1.8	1.2	1.1
Carbonate (deeply weathered, silty, deeply wea	42													0.3	0.2	0.5	0.3
Carbonate (sandy, soft)	40																
Chert-Cherty Carbonate (<20% leached chert)	26	1.1	1.5	0.9	1.1	0.9	0.8	1.1	1.0		2.2	1.4	1.2	0.7	0.7	0.6	0.7
Conglomerate-Sandstone-Arkose (brittle)	30	0.1	0.6	0.2	0.3	1.0	0.4	0.6	0.7								
Greywacke (brittle)	29									0.4	0.8	0.1	0.4		0.4	1.3	0.6
Encrustation	52	0.4	0.5	0.1	0.3	0.9	1.0		0.6								
Gneiss - Amphibolite - Schist (brittle)	25	1.0	1.8	1.9	1.6	0.7	1.1	1.8	1.2	2.9	4.4	2.1	3.1	2.2	6.2	2.9	3.6
Argilite (medium soft)	34									0.4			0.1				
Granite - Diorite - Gabbro (brittle)	27	1.2	2.1	2.7	2.0	1.3	2.6	3.6	2.5	1.6	2.1	2.0	1.9	0.4	0.9	0.3	0.5
Volcanic (soft)	28																
Iron Formation	82																
Total Fair Aggregate (%)		**5.0**	**7.6**	**6.7**	**6.4**	**6.1**	**6.9**	**8.5**	**7.2**	**6.3**	**10.5**	**7.4**	**8.0**	**4.0**	**10.2**	**6.8**	**6.8**
Carbonate (shaley, clayey, silty, clayey)	43					0.3			0.1								
Carbonate (ochreous, sandy, ochreous)	44																
Chert-Cherty Carbonate (>20% leached chert)	45	0.9	0.8	1.4	1.1	1.0	0.6	0.5	0.7					0.4			0.1
Conglomerate-Sandstone-Arkose (friable)	46																
Siltstone	56	0.2			0.1	0.1		1.2	0.5								
Cementation (partial)	53	0.3			0.1												
Gneiss-Amphibolite (friable)	50									0.4			0.1			0.7	0.3
Schist (soft)	55																
Granite-Diorite-Gabbro (friable)	51																
Volcanic (very soft, porous)	48																
IRON FORMATION (highly weathered)	84																
Total poor Aggregate (%)		**1.4**	**0.8**	**1.4**	**1.2**	**1.5**	**0.6**	**1.8**	**1.3**	**0.4**			**0.1**	**0.4**		**0.7**	**0.4**
Ochre	60																
Shale	61																
Clay	62																
Volcanic-Gneiss-Schist (decomposed)	63																
Carbonate (very weak, deeply weathered)	64																
Total Deleterious Aggregate (%)																	
Reported Total Mass Examined (g)		**1544.2**	**529.5**	***207.2***		**1547.7**	**541.8**	***227.3***		**1537.8**	**525.7**	***217.4***		**1536.9**	**522.5**	***217.1***	
% GOOD	X 1 =	93.6	91.6	91.9		92.5	92.5	89.7		nr	nr	nr		nr	nr	nr	
% FAIR	X 3 =	15.0	22.7	20.1		18.3	20.7	25.5		nr	nr	nr		nr	nr	nr	
% POOR	X 6 =	8.4	5.1	8.4		8.8	3.3	10.6		nr	nr	nr		nr	nr	nr	
% DELETERIOUS	X 10 =									nr	nr	nr		nr	nr	nr	
PETROGRAPHIC NUMBER		117.0	119.4	120.4		119.5	116.6	125.8		nr	nr	nr		nr	nr	nr	
WTD. AVG. PETROGRAPHIC NUMBER		**118.9**				**120.8**				**116.5**				**115.6**			

Laboratory Number		31				31				35				35			
Sample Number		1.15				2.15				1.15				2.15			
Rock Type/Fraction		R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %
Carbonate (hard, silty, hard)	1									6.6	8.8	19.0	11.6	5.6	15.5	15.3	12.0
Carbonate (surf. Weath., silty, surf. Weath., med. Hard; silty, med. Hard)	20	12.8	16.4	17.9	15.7	11.7	12.8	18.8	14.5	3.3	1.2	3.5	2.7	0.9	0.9	1.2	1.0
Carbonate (sandy, hard or medium hard)	2																
Carbonate (slightly cherty <5%)	21	1.9	2.7	2.7	2.4	2.8	2.0	4.0	3.0								
Marble (hard or medium hard)	23																
Conglomerate-Sandstone-Arkose (hard)	3	0.8	1.0	0.5	0.8	1.7		0.6	0.8	3.9	3.6	2.6	3.3	1.4	2.0	2.0	1.8
Conglomerate-Sandstone-Arkose (medium har	22					1.2	1.6		0.9								
Greywacke - Argillite (hard or medium hard)	6	24.1	24.9	24.6	24.5	31.8	30.2	22.3	28.0	2.1	1.4	2.4	2.0	0.8	0.7	2.9	1.5
Gneiss - Amphibolite - Schist (hard)	4	50.4	40.8	44.6	45.5	37.2	41.4	42.3	40.2	43.8	36.5	33.9	38.1	43.9	39.8	39.5	41.1
Quartzite	5		0.8	0.5	0.4			0.3	0.1								
Granite - Diorite - Gabbro (hard)	8	3.5	3.7	4.1	3.8	7.8	3.7	3.1	4.9	12.8	12.7	7.6	11.0	6.6	5.2	4.2	6.0
Volcanic (hard or medium hard)	7						1.5		0.4	0.6	1.1	0.5	0.7			0.3	0.1
Trap (≤20% sulphide)	9									21.8	30.0	26.0	25.7	34.3	29.9	29.1	31.2
Quartz (vein or pegmatitic)	10			0.1	0.0					0.3	0.4		0.2	0.4			0.1
Feldspar	11																
Iron Formation	71																
Red Jasper - Flint	81																
Orthoquartzite																	
Metasedimentary (hard)																	
Metavolcanic (hard)																	
Total Good Aggregate (%)		**93.5**	**90.4**	**95.1**	**93.1**	**94.2**	**93.2**	**91.4**	**92.9**	**95.2**	**95.0**	**95.4**	**95.4**	**95.8**	**94.0**	**94.5**	**94.8**
Carbonate (soft, silty, soft, slightly shaley)	35	1.1	2.4	1.2	1.5	0.6	2.8	1.9	1.7	2.5	1.5	1.9	2.0	1.0	2.0	0.5	1.1
Carbonate (soft, pitted)	41																
Carbonate (deeply weathered, silty, deeply wea	42									0.3	0.5		0.3	0.4	0.7		0.3
Carbonate (sandy, soft)	40																
Chert-Cherty Carbonate (<20% leached chert)	26									1.1	0.4	0.5	0.7	1.1	0.7	2.5	1.5
Conglomerate-Sandstone-Arkose (brittle)	30							0.6	0.2								
Greywacke (brittle)	29			0.9	0.3	1.1		1.5	0.9						1.1		0.3
Encrustation	52										0.3		0.1				
Gneiss - Amphibolite - Schist (brittle)	25	4.7	4.3	2.9	3.9	3.2	3.1	4.4	3.6	0.3	0.2	0.1	0.2	0.2	0.2		0.1
Argillite (medium soft)	34													0.9	0.3		0.4
Granite - Diorite - Gabbro (brittle)	27		2.6		0.8	0.4	0.8	0.2	0.5								
Volcanic (soft)	28																
Iron Formation	82																
Total Fair Aggregate (%)		**5.8**	**9.3**	**4.9**	**6.5**	**5.4**	**6.8**	**8.6**	**6.9**	**4.2**	**3.0**	**2.6**	**3.3**	**3.5**	**5.0**	**3.1**	**3.8**
Carbonate (shaley, clayey, silty, clayey)	43		0.4		0.1	0.5	0.1		0.2	0.3	0.3	0.1	0.2	0.3	0.2	0.2	0.2
Carbonate (ochreous, sandy, ochreous)	44	0.2			0.1												
Chert-Cherty Carbonate (>20% leached chert)	45									0.3	1.0	2.0	1.1	0.4	0.8	2.2	1.1
Conglomerate-Sandstone-Arkose (friable)	46																
Siltstone	56																
Cementation (partial)	53																
Gneiss-Amphibolite (friable)	50																
Schist (soft)	55	0.5			0.2												
Granite-Diorite-Gabbro (friable)	51																
Volcanic (very soft, porous)	48																
IRON FORMATION (highly weathered)	84																
Total poor Aggregate (%)		**0.7**	**0.4**		**0.4**	**0.5**	**0.1**		**0.2**	**0.6**	**1.3**	**2.0**	**1.3**	**0.7**	**1.0**	**2.4**	**1.4**
Ochre	60																
Shale	61																
Clay	62																
Volcanic-Gneiss-Schist (decomposed)	63																
Carbonate (very weak, deeply weathered)	64																
Total Deleterious Aggregate (%)																	
Reported Total Mass Examined (g)		**1526.9**	**529.6**	**214.0**		**1531.0**	**517.5**	**209.6**		**1538.6**	**533.8**	**215.3**		**1540.3**	**523.6**	**208.8**	
% GOOD	X 1 =	93.5	90.4	95.1		94.2	93.2	91.4		95.2	95.0	95.4		95.8	94.0	94.5	
% FAIR	X 3 =	17.4	27.8	14.7		16.1	20.3	25.8		12.7	8.9	7.7		10.6	15.1	9.2	
% POOR	X 6 =	4.2	2.2			2.9	0.5			3.6	7.6	12.3		4.1	6.1	14.4	
% DELETERIOUS	X 10 =																
PETROGRAPHIC NUMBER		115.1	120.3	109.8		113.1	113.9	117.2		111.4	112.3	115.3		110.5	115.1	118.1	
WTD. AVG. PETROGRAPHIC NUMBER		**114.8**				**114.8**				**113.1**				**114.5**			

Laboratory Number		38				38				39				39			
Sample Number		1.15				2.15				1.15				2.15			
Rock Type/Fraction		R13.2	R9.5	R4.75	Wt.%	R13.2	R9.5	R4.75	Wt.%	R13.2	R9.5	R4.75	Wt.%	R13.2	R9.5	R4.75	Wt.%
Carbonate (hard, silty, hard)	1									10.7	15.4	27.8	18.1	10.5	15.0	30.2	18.7
Carbonate (surf. Weath., silty, surf. Weath., med. Hard, silty, med. Hard)	20	8.0	6.4	9.2	7.9	10.6	11.6	18.2	13.6		1.4		0.4		1.0		0.3
Carbonate (sandy, hard or medium hard)	2													1.0		1.4	0.8
Carbonate (slightly cherty, <5%)	21									1.1	1.3	1.0	1.1		1.4		0.4
Marble (hard or medium hard)	23																
Conglomerate-Sandstone-Arkose (hard)	3	3.8	3.2	2.0	3.0	2.1	0.3	1.4	1.3	4.4	1.4		2.0	4.3	1.4		1.9
Conglomerate-Sandstone-Arkose (medium har	22										0.4		0.1		0.4		0.1
Greywacke - Argillite (hard or medium hard)	6	36.8	26.6	29.8	31.3	22.0	39.0	34.5	31.5		12.4	8.7	6.7		11.8	7.9	6.3
Gneiss - Amphibolite - Schist (hard)	4									11.0	9.9		6.8	10.8	9.2		6.5
Quartzite	5									0.7			0.2	0.7			0.2
Granite - Diorite - Gabbro (hard)	8	39.8	48.2	40.2	42.5	53.6	39.7	34.1	42.6	46.0	33.8	44.7	41.9	45.7	35.4	45.3	42.4
Volcanic (hard or medium hard)	7		0.7		0.2												
Trap (≤20% sulphide)	9									18.7	17.7	11.7	15.9	20.0	18.3	9.4	15.8
Quartz (vein or pegmatitic)	10	0.3			0.1												
Feldspar	11																
Iron Formation	71	0.5	0.5		0.3												
Red Jasper - Flint	81																
Orthoquartzite																	
Metasedimentary (hard)																	
Metavolcanic (hard)																	
Total Good Aggregate (%)		89.2	85.5	81.3	85.3	88.3	90.6	88.2	88.9	92.6	93.7	93.8	93.3	92.9	93.9	94.1	93.6
Carbonate (soft, silty, soft, slightly shaley)	35																
Carbonate (soft, pitted)	41																
Carbonate (deeply weathered, silty, deeply wea	42	3.1	2.5	0.4	1.9	5.8	1.6	2.5	3.4	1.2			0.4	1.1			0.4
Carbonate (sandy, soft)	40													0.0			
Chert-Cherty Carbonate (<20% leached chert)	26	3.4	6.7	13.5	7.9	2.4	2.9	4.3	3.2								
Conglomerate-Sandstone-Arkose (brittle)	30																
Greywacke (brittle)	29																
Encrustation	52																
Gneiss - Amphibolite - Schist (brittle)	25											0.6	0.2			1.0	0.3
Argillite (medium soft)	34										5.5	5.6	3.6		5.0		1.5
Granite - Diorite - Gabbro (brittle)	27	4.2	5.4	4.8	4.8	3.1	5.0	5.0	4.4	6.0			2.1	5.8			2.0
Volcanic (soft)	28															4.9	1.7
Iron Formation	82																
Total Fair Aggregate (%)		10.6	14.5	18.7	14.6	11.3	9.4	11.8	10.9	7.3	5.5	6.2	6.4	6.9	5.0	5.9	6.0
Carbonate (shaley, clayey, silty, clayey)	43																
Carbonate (ochreous, sandy, ochreous)	44																
Chert-Cherty Carbonate (>20% leached chert)	45																
Conglomerate-Sandstone-Arkose (friable)	46																
Siltstone	56																
Cementation (partial)	53																
Gneiss-Amphibolite (friable)	50																
Schist (soft)	55																
Granite-Diorite-Gabbro (friable)	51					0.4			0.1		0.8		0.3		1.1		0.3
Volcanic (very soft, porous)	48																
IRON FORMATION (highly weathered)	84																
Total poor Aggregate (%)						0.4			0.1		0.8		0.3		1.1		0.3
Ochre	60									0.1				0.2			0.1
Shale	61																
Clay	62	0.2			0.1												
Volcanic-Gneiss-Schist (decomposed)	63																
Carbonate (very weak, deeply weathered)	64																
Total Deleterious Aggregate (%)		0.2			0.1					0.1				0.2			0.1
Reported Total Mass Examined (g)		1530.2	534.4	212.9		1540.0	522.0	208.9		1541.7	532.6	218.0		1537.9	524.3	221.0	
% GOOD	x 1 =	89.2	85.5	81.3		88.3	90.6	88.2		92.6	93.7	93.8		92.9	93.9	94.1	
% FAIR	x 3 =	31.9	43.6	56.2		34.0	28.3	35.5		21.8	16.4	18.7		20.8	15.0	17.6	
% POOR	x 6 =					2.2					5.1				6.6		
% DELETERIOUS	x 10 =	1.7								1.4				2.0			
PETROGRAPHIC NUMBER		122.8	129.0	137.5		124.5	118.9	123.6		115.8	115.2	112.5		115.7	115.6	111.8	
WTD. AVG. PETROGRAPHIC NUMBER			129.8				122.5				114.4				114.3		

Laboratory Number		40				40				47				47			
Sample Number		1.15				2.15				1.15				2.15			
Rock Type/Fraction		R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %
Carbonate (hard, silty, hard)	1					10.7			3.7	3.1	4.4	4.9	4.1	5.2	5.2	8.4	6.3
Carbonate (surf. Weath., silty, surf. Weath., med. Hard, silty, med. Hard)	20	9.2	10.1	13.2	10.9	4.0	13.2	21.1	12.7	4.7	4.2	5.9	5.0	2.5	1.7	5.6	3.3
Carbonate (sandy, hard or medium hard)	2	3.7		4.1	2.7	2.5	3.0		1.8	0.6		0.5	0.4			0.5	0.2
Carbonate (slightly cherty <5%)	21											0.5	0.2	1.4			0.5
Marble (hard or medium hard)	23																
Conglomerate-Sandstone-Arkose (hard)	3	5.2	15.8	5.5	8.5	1.0	8.3	6.6	5.2	0.6		1.0	0.5				
Conglomerate-Sandstone-Arkose (medium har	22																
Greywacke - Argillite (hard or medium hard)	6	20.5	19.8	29.2	23.4	24.8	18.9	30.5	25.0	2.9	4.4	6.3	4.5	8.6	6.9	10.7	8.8
Gneiss - Amphibolite - Schist (hard)	4	27.9	25.7	24.7	25.1	30.5	27.2	14.1	23.8	25.4	18.3	8.8	17.5	14.9	6.3	9.3	10.4
Quartzite	5	0.3			0.1	0.5			0.2	2.3	0.8		1.0	0.4	0.8	0.0	0.4
Granite - Diorite - Gabbro (hard)	8	24.4	20.5	14.2	19.7	23.0	23.4	23.9	23.5	24.4	31.5	29.8	28.4	43.1	49.6	30.2	40.6
Volcanic (hard or medium hard)	7	0.6			0.2					1.8		1.5	1.1	2.1		4.2	2.2
Trap (≤20% sulphide)	9									0.2	1.2	0.5	0.6	0.7		0.5	0.4
Quartz (vein or pegmatite)	10										0.6	0.5	0.3		1.0	0.9	0.6
Feldspar	11															0.5	0.2
Iron Formation	71																
Red Jasper - Flint	81																
Orthoquartzite																	
Metasedimentary (hard)										5.8	5.0	4.9	5.2	0.7	1.0	0.9	0.9
Metavolcanic (hard)										21.3	18.7	16.6	18.9	14.5	15.0	17.2	15.6
Total Good Aggregate (%)		91.8	91.8	90.9	91.5	97.1	94.0	96.2	95.9	93.1	89.2	81.5	87.8	94.0	87.5	88.8	90.2
Carbonate (soft, silty, soft, slightly shaley)	35																
Carbonate (soft, pitted)	41	3.3	3.4	0.5	2.3		1.5		0.5	1.4	2.5	2.9	2.3	0.3	2.3		0.8
Carbonate (deeply weathered, silty, deeply wea	42	1.0		4.6	1.9					1.2	2.3	3.9	2.5	2.1	4.8	3.3	3.3
Carbonate (sandy, soft)	40											0.5	0.2				
Chert-Cherty Carbonate (<20% leached chert)	26		1.3	1.4	0.9	0.3	1.9	0.5	0.8	1.0	1.9	2.9	2.0	1.6	2.9	1.9	2.1
Conglomerate-Sandstone-Arkose (brittle)	30																
Greywacke (brittle)	29									0.3			0.1				
Encrustation	52									0.9	0.4	2.0	1.1	0.9		0.5	0.5
Gneiss - Amphibolite - Schist (brittle)	25	1.3			0.5	0.6	0.8		0.4	1.3	0.4	2.9	1.6		0.4		0.1
Argillite (medium soft)	34																
Granite - Diorite - Gabbro (brittle)	27									0.2	2.7		0.9			1.9	0.7
Volcanic (soft)	28																
Iron Formation	82																
Total Fair Aggregate (%)		5.6	4.8	6.4	5.6	0.8	4.2	0.5	1.7	6.4	10.2	15.1	10.6	4.9	10.4	7.4	7.5
Carbonate (shaley, clayey, silty, clayey)	43		0.6		0.2					0.3	0.6	0.5	0.4	0.7	1.5	1.4	1.2
Carbonate (ochreous, sandy, ochreous)	44																
Chert-Cherty Carbonate (>20% leached chert)	45	2.0	0.6	2.7	1.8	2.1	1.9	2.8	2.3	0.3		2.4	0.9	0.3	0.6	1.9	0.9
Conglomerate-Sandstone-Arkose (friable)	46																
Siltstone	56		1.7		0.5												
Cementation (partial)	53	0.3			0.1												
Gneiss-Amphibolite (friable)	50	0.5			0.2							0.5	0.2				
Schist (soft)	55																
Granite-Diorite-Gabbro (friable)	51															0.5	0.2
Volcanic (very soft, porous)	48																
IRON FORMATION (highly weathered)	84																
Total poor Aggregate (%)		2.7	2.9	2.7	2.8	2.1	1.9	2.8	2.3	0.5	0.6	2.4	1.6	1.0	2.1	3.7	2.3
Ochre	60																
Shale	61																
Clay	62							0.5	0.2								
Volcanic Gneiss-Schist (decomposed)	63		0.6		0.2												
Carbonate (very weak, deeply weathered)	64																
Total Deleterious Aggregate (%)			0.6		0.2			0.5	0.2								
Reported Total Mass Examined (g)		1528.0	526.0	219.0		1538.0	530.0	213.0		1543.0	518.0	205.0		1537.0	520.0	215.0	
% GOOD	X 1 =	91.8	91.8	90.9		97.1	94.0	96.2		93.1	89.2	81.5		94.0	87.5	88.8	
% FAIR	X 3 =	16.7	14.3	19.2		2.5	12.5	1.4		19.2	30.7	45.4		14.8	31.2	22.3	
% POOR	X 6 =	16.1	17.1	16.4		12.5	11.3	16.9		3.1	3.5	20.5		6.2	12.7	22.3	
% DELETERIOUS	X 10 =		5.7			0.0		4.7		0.0		0.0		0.0		0.0	
PETROGRAPHIC NUMBER		124.5	128.9	126.5		112.1	117.7	119.2		115.4	123.4	147.3		115.1	131.3	139.5	
WTD. AVG. PETROGRAPHIC NUMBER			126.5				116.3				129.0				126.4		

Laboratory Number		61				61				76				76			
Sample Number		1.15				2.15				1.15				2.15			
Rock Type/Fraction		R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %
Carbonate (hard, silty, hard)	1	90	80	198	125	109	128	84	106	54	94	118	88	76	71	143	98
Carbonate (surf. Weath., silty, surf. Weath., med. Hard, silty, med. Hard)	20									36	44	63	48	29	54	66	50
Carbonate (sandy, hard or medium hard)	2																
Carbonate (slightly cherty <5%)	21																
Marble (hard or medium hard)	23																
Conglomerate-Sandstone-Arkose (hard)	3	55	15	09	27	13	08		07	07	24	07	12	21	15	05	14
Conglomerate-Sandstone-Arkose (medium har	22																
Greywacke - Argillite (hard or medium hard)	6	300	127	228	223	204	242	156	199	141	182	188	170	134	148	168	150
Gneiss - Amphibolite - Schist (hard)	4	145	76	102	109	52	32	112	67	77	47	18	47	28	34	14	25
Quartzite	5	15	08	10	11	34	11	16	21								
Granite - Diorite - Gabbro (hard)	8	331	588	359	418	482	520	536	513	402	371	366	380	457	395	353	399
Volcanic (hard or medium hard)	7									43	17	23	28	26	25	17	23
Trap (≤20% sulphide)	9														12	02	04
Quartz (vein or pegmatite)	10										06		02		03	03	02
Feldspar	11																
Iron Formation	71																
Red Jasper - Flint	81																
Orthoquartzite																	
Metasedimentary (hard)																	
Metavolcanic (hard)																	
Total Good Aggregate (%)		93.5	89.3	90.7	91.3	89.4	94.1	90.4	91.2	76.0	78.6	78.3	77.6	77.1	74.9	77.2	76.5
Carbonate (soft, silty, soft, slightly shaley)	35										16	18	11	14	17	04	11
Carbonate (soft, pitted)	41					03	07	16	09								
Carbonate (deeply weathered, silty, deeply wea	42					04		12	06	12	09	13	11	05	14	11	09
Carbonate (sandy, soft)	40	18	35	42	32	14			05								
Chert-Cherty Carbonate (<20% leached chert)	26	03	07	18	10	13	21		11	07	23	18	16	16	36	23	25
Conglomerate-Sandstone-Arkose (brittle)	30																
Greywacke (brittle)	29									79	78	40	65	86	76	52	71
Encrustation	52										05		02				
Gneiss - Amphibolite - Schist (brittle)	25	29	56	25	35	27			09	40	16	27	28	19	05	06	10
Argillite (medium soft)	34									05		22	09			14	05
Granite - Diorite - Gabbro (brittle)	27	06			02	28	17	44	30	63	25	42	44	47	60	72	59
Volcanic (soft)	28									17	03	07	09	16	10	08	11
Iron Formation	82																
Total Fair Aggregate (%)		5.6	9.0	8.5	7.9	8.9	4.4	7.2	7.0	22.3	17.6	18.6	19.6	20.1	21.8	19.0	20.2
Carbonate (shaley, clayey, silty, clayey)	43					08	15	15	13		10	03	04		06		02
Carbonate (ochreous, sandy, ochreous)	44																
Chert-Cherty Carbonate (>20% leached chert)	45	08	05		04	03		09	04	03	22	16	13	06	07	16	09
Conglomerate-Sandstone-Arkose (friable)	46													07	06		04
Siltstone	56																
Cementation (partial)	53																
Gneiss-Amphibolite (friable)	50		04	08	04	06			02	07		04	04	08			03
Schist (soft)	55																
Granite-Diorite-Gabbro (friable)	51									03	02	05	03	02	14	20	12
Volcanic (very soft, porous)	48									00	03		01			02	01
IRON FORMATION (highly weathered)	84																
Total poor Aggregate (%)		0.8	0.9	0.8	0.9	1.8	1.5	2.3	1.9	1.3	3.7	2.1	2.5	2.2	3.2	3.8	3.0
Ochre	60													05			02
Shale	61																
Clay	62																
Volcanic-Gneiss-Schist (decomposed)	63									04		03	03		02		01
Carbonate (very weak, deeply weathered)	64																
Total Deleterious Aggregate (%)										0.4		0.3	0.3	0.5	0.2		0.2
Reported Total Mass Examined (g)		1536.5	523.2	212.6		1530.4	533.0	219.6		1532.1	515.5	204.4		1524.1	521.9	206.3	
% GOOD	X1=	935	893	907		894	941	904		760	786	783		771	749	772	
% FAIR	X3=	169	264	255		266	133	217		670	529	558		604	653	571	
% POOR	X6=	50	56	48		105	89	139		78	225	164		133	190	227	
% DELETERIOUS	X10=	00	00	00		00	00	00		40	00	34		52	19	00	
PETROGRAPHIC NUMBER		115.0	124.0	121.0		127.0	116.0	126.0		154.7	154.0	154.0		156.0	161.1	157.0	
WTD. AVG. PETROGRAPHIC NUMBER			120.0				123.0				154.2				157.9		

Laboratory Number		11				11				80				80			
Sample Number		1.15				2.15				1.15				2.15			
Rock Type/Fraction		R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %
Carbonate (hard, silty, hard)	1	8.3	16.0	1.8	8.3	13.8	15.1	14.4	14.7	11.9	12.3	18.9	**12.7**	12.8	9.4	21.2	**12.8**
Carbonate (surf. Weath., silty, surf. Weath., med. Hard, silty, med. Hard)	20	8.3	11.1	20.3	13.4	13.8	9.6	16.1	13.3	5.5	2.9	0.7	**4.4**	0.7		1.1	**0.6**
Carbonate (sandy, hard or medium hard)	2																
Carbonate (slightly cherty <5%)	21													1.0			**0.7**
Marble (hard or medium hard)	23																
Conglomerate-Sandstone-Arkose (hard)	3									1.9	0.5	1.6	**1.6**				
Conglomerate-Sandstone-Arkose (medium har	22											0.6	**0.1**				
Greywacke - Argillite (hard or medium hard)	6	25.9	23.0	36.0	28.2	20.6	19.9	22.4	21.0	25.4	24.4	27.3	**25.4**	27.6	24.2	20.6	**26.2**
Gneiss - Amphibolite - Schist (hard)	4									9.8	9.2	1.9	**8.9**	10.7	9.4	4.6	**9.9**
Quartzite	5									2.4	3.4	6.1	**3.0**	1.7	3.6	4.3	**2.4**
Granite - Diorite - Gabbro (hard)	8	50.4	48.5	40.2	46.3	48.2	50.1	43.0	46.9	35.8	42.3	33.8	**37.1**	24.5	36.9	32.5	**28.1**
Volcanic (hard or medium hard)	7	1.3			0.5		1.6	1.2	0.9	5.3	2.0	3.5	**4.4**	14.5	5.9	13.5	**12.4**
Trap (≥20% sulphide)	9													4.0	7.2		**4.4**
Quartz (vein or pegmatite)	10	0.8	0.5	1.1	0.8	0.1		0.8	0.3								
Feldspar	11																
Iron Formation	31																
Red Jasper - Flint	81																
Orthoquartzite																	
Metasedimentary (hard)																	
Metavolcanic (hard)																	
Total Good Aggregate (%)		**95.1**	**99.1**	**98.4**	**97.5**	**96.5**	**97.2**	**97.0**	**97.2**	**98.0**	**97.2**	**94.5**	**97.5**	**97.5**	**96.7**	**97.1**	**97.3**
Carbonate (soft, silty, soft, slightly shaley)	35	2.2			0.8												
Carbonate (soft, pitted)	41										0.9	0.5	**0.3**				
Carbonate (deeply weathered, silty, deeply wea	42																
Carbonate (sandy, soft)	40	2.5			0.9	2.1	2.6	1.4	2.0							0.2	
Chert-Cherty Carbonate (<20% leached chert)	26	0.2	0.9	1.6	0.9	1.4	0.3	0.7	0.8	0.9	1.9	2.1	**1.3**		2.9	0.2	**0.7**
Conglomerate-Sandstone-Arkose (brittle)	30																
Greywacke (brittle)	29																
Encrustation	52																
Gneiss - Amphibolite - Schist (brittle)	25																
Argillite (medium soft)	34																
Granite - Diorite - Gabbro (brittle)	27									0.9			**0.6**	0.4			**0.3**
Volcanic (soft)	28																
Iron Formation	82																
Total Fair Aggregate (%)		**4.9**	**0.9**	**1.6**	**2.5**	**3.5**	**2.8**	**2.2**	**2.8**	**1.8**	**2.8**	**2.6**	**2.1**	**0.4**	**2.9**	**0.4**	**1.0**
Carbonate (shaley, clayey, silty, clayey)	43																
Carbonate (ochreous, sandy, ochreous)	44											0.5	**0.1**			0.6	**0.1**
Chert-Cherty Carbonate (<20% leached chert)	45											2.4	**0.2**	2.1		1.3	**1.6**
Conglomerate-Sandstone-Arkose (friable)	46																
Siltstone	56														0.4		**0.1**
Cementation (partial)	53																
Gneiss-Amphibolite (friable)	50																
Schist (soft)	55																
Granite-Diorite-Gabbro (friable)	51																
Volcanic (very soft, porous)	48									0.2			**0.2**				
IRON FORMATION (highly weathered)	84																
Total poor Aggregate (%)										**0.2**		**2.9**	**0.4**	**2.1**	**0.4**	**1.9**	**1.7**
Ochre	60																
Shale	61																
Clay	62																
Volcanic-Gneiss-Schist (decomposed)	63																
Carbonate (very weak, deeply weathered)	64																
Total Deleterious Aggregate (%)																	
Reported Total Mass Examined (g)		**1534.6**	**530.2**	**218.1**		**1526.5**	**520.8**	**215.9**		**1583.7**	**526.6**	**226.0**		**1533.2**	**517.6**	**209.3**	
% GOOD	X 1 =	95.1	99.1	98.4		96.5	97.2	97.0		98.0	97.2	94.5		97.5	96.7	97.7	
% FAIR	X 3 =	14.7	2.8	4.7		10.4	8.5	6.5		5.3	8.5	7.8		1.2	8.8	1.3	
% POOR	X 6 =	0.0	0.0	0.0		0.0	0.0	0.0		1.4	0.0	17.5		12.7	2.4	11.5	
% DELETERIOUS	X 10 =	0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0		0.0	0.0	0.0	
PETROGRAPHIC NUMBER		109.8	101.8	103.1		106.9	105.7	104.4		104.7	105.7	119.8		111.4	107.9	110.4	
WTD. AVG. PETROGRAPHIC NUMBER		**105.1**				**105.7**				**106.0**				**110.0**			

Laboratory Number		81				81				96				96			
Sample Number		1.15				2.15				1.15				2.15			
Rock Type/Fraction		R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %
Carbonate (hard, silty, hard)	1	3.6	5.5	7.8	5.6	4.1	3.7	6.4	4.8	8.4	11.1	12.3	nr	4.1	6.8	14.5	nr
Carbonate (surf. Weath., silty, surf. Weath., med. Hard, silty, med. Hard)	20	6.1	10.6	11.8	9.4	7.8	10.2	9.5	9.1	2.4	2.3	9.2	nr	5.7	6.7	4.4	nr
Carbonate (sandy, hard or medium hard)	2												nr			0.5	nr
Carbonate (slightly cherty <5%)	21					1.1	1.1	1.0	1.1				nr				nr
Marble (hard or medium hard)	23												nr				nr
Conglomerate-Sandstone-Arkose (hard)	3	0.4			0.1					1.8	2.0	1.5	nr	4.0	0.7	2.5	nr
Conglomerate-Sandstone-Arkose (medium har	22			0.4	0.1								nr				nr
Greywacke - Argillite (hard or medium hard)	6					3.7	2.5	4.0	3.5				nr				nr
Gneiss - Amphibolite - Schist (hard)	4	14.8	7.7	3.0	8.5	9.9	7.4	5.5	7.6	46.5	43.5	33.3	nr	44.9	43.3	36.0	nr
Quartzite	5	0.6	1.8	1.2	1.2		2.6	2.1	1.5	0.5	0.6		nr	0.3	0.6	0.3	nr
Granite - Diorite - Gabbro (hard)	8	35.7	39.5	35.1	36.6	39.3	34.1	31.2	34.9	19.9	21.2	26.2	nr	14.3	22.1	24.2	nr
Volcanic (hard or medium hard)	7	34.2	28.7	36.1	33.2	29.0	31.2	33.0	31.1	0.8	0.5	1.7	nr	1.5	0.5	0.7	nr
Trap (≤20% sulphide)	9									18.1	16.5	10.9	nr	20.5	13.9	8.7	nr
Quartz (vein or pegmatite)	10		0.3	0.4	0.2								nr				
Feldspar	11																
Iron Formation	71																
Red Jasper - Flint	81																
Orthoquartzite																	
Metasedementary (hard)																	
Metavolcanic (hard)																	
Total Good Aggregate (%)		95.4	93.9	95.7	95.1	94.9	92.8	92.7	93.5	98.4	97.6	95.2	nr	95.4	94.7	91.7	nr
Carbonate (soft, silty, soft, slightly shaley)	35									0.4		2.2	nr	1.6	1.7	3.9	nr
Carbonate (soft, pitted)	41												nr				
Carbonate (deeply weathered, silty, deeply wea	42	0.9	0.6	0.4	0.7	0.5		0.9	0.5				nr				
Carbonate (sandy, soft)	40												nr				
Chert-Cherty Carbonate (<20% leached chert)	26		1.2	0.5	0.5	1.0	1.6	0.5	1.0				nr				
Conglomerate-Sandstone-Arkose (brittle)	30												nr				
Greywacke (brittle)	29												nr				
Encrustation	52									0.7		0.2	nr	0.6			
Gneiss - Amphibolite - Schist (brittle)	25	0.5		1.2	0.6		0.4	0.8	0.4		0.4	0.1	nr	0.7	0.8	1.6	nr
Argillite (medium soft)	34												nr				
Granite - Diorite - Gabbro (brittle)	27	1.1	1.2	0.4	0.9	0.8	2.3		1.0				nr				
Volcanic (soft)	28						0.5	1.5	0.7				nr				
Iron Formation	82																
Total Fair Aggregate (%)		2.5	3.0	2.6	2.7	2.3	4.8	3.7	3.5	1.1	0.4	2.5	nr	2.9	2.5	5.5	nr
Carbonate (shaley, clayey, silty, clayey)	43	0.6	0.9	0.2	0.5			0.5	0.2			0.1	nr			0.8	nr
Carbonate (ochreous, sandy, ochreous)	44												nr				
Chert-Cherty Carbonate (>20% leached chert)	45	1.5	2.1	1.3	1.6	2.8	2.4	2.1	2.4	0.5	2.0	2.2	nr	1.4	2.7	1.5	nr
Conglomerate-Sandstone-Arkose (friable)	46												nr			0.1	nr
Siltstone	56												nr				
Cementation (partial)	53												nr	0.4		0.3	nr
Gneiss-Amphibolite (friable)	50			0.2	0.1			1.0	0.4				nr			0.1	nr
Schist (soft)	55												nr				
Granite-Diorite-Gabbro (friable)	51												nr				
Volcanic (very soft, porous)	48												nr				
IRON FORMATION (highly weathered)	84																
Total poor Aggregate (%)		2.1	3.0	1.7	2.2	2.8	2.4	3.6	3.0	0.5	2.0	2.3	nr	1.8	2.7	2.8	nr
Ochre	60																
Shale	61														0.2		
Clay	62																
Volcanic-Gneiss-Schist (decomposed)	63																
Carbonate (very weak, deeply weathered)	64																
Total Deleterious Aggregate (%)															0.2		
Reported Total Mass Examined (g)		1547.5	523.2	210.1		1531.5	538.0	210.4		1552.7	526.7	218.7		1534.6	513.1	222.5	
% GOOD	X 1 =	95.4	93.9	95.7		94.9	92.8	92.7		98.4	97.6	95.2		95.4	94.7	91.7	
% FAIR	X 3 =	7.6	9.1	7.7		6.9	14.3	11.1		1.1	0.4	2.5		2.9	2.5	5.0	
% POOR	X 6 =	12.6	18.2	10.3		16.8	14.5	21.7		0.5	2.0	2.3		1.8	2.7	2.8	
% DELETERIOUS	X 10 =						0.0				0.0				0.2		
PETROGRAPHIC NUMBER		115.5	121.2	113.7		118.6	121.6	125.5		104.6	110.7	116.7		114.6	119.7	124.9	
WTD. AVG. PETROGRAPHIC NUMBER		116.6				121.9				110.7				119.7			

Laboratory Number		88				89				96				96			
Sample Number		1.15				2.15				1.15				2.15			
Rock Type/Fraction		R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %
Carbonate (hard, silty, hard)	1	4.9	4.3	9.2	6.2	8.5	3.8	15.6	9.6	9.4	9.5	13.8	11.0	10.9	9.3	14.0	11.5
Carbonate (surf. Weath., silty, surf. Weath., med. Hard, silty, med. Hard)	20	1.8	4.6	5.6	3.9	6.8	4.1	5.4	5.5	5.5	2.8	4.8	4.5	2.2	2.3	3.1	2.6
Carbonate (sandy, hard or medium hard)	2	0.0								1.3	0.0	0.4	0.6			0.8	0.3
Carbonate (slightly cherty: <5%)	21	0.6		0.3	0.3							0.7	0.2		0.2	1.3	0.5
Marble (hard or medium hard)	23																
Conglomerate-Sandstone-Arkose (hard)	3	22.9	23.7	27.1	24.6	21.4	26.5	23.1	23.5	19.5	18.1	18.1	18.6	14.1	21.8	19.2	18.2
Conglomerate-Sandstone-Arkose (medium har	22	3.3	5.9	1.0	3.3	3.2	3.4	3.6	3.4								
Greywacke - Argillite (hard or medium hard)	6	0.0		0.0	0.0									0.8			0.3
Gneiss - Amphibolite - Schist (hard)	4	19.5	11.2	5.5	12.1	13.4	5.7	4.6	8.0	19.0	21.3	16.1	18.6	20.1	24.1	14.5	19.4
Quartzite	5	2.0	1.6	0.8	1.4	3.2	2.4	1.6	2.4	3.2	2.7	2.6	2.8	1.9	0.9	3.0	2.0
Granite - Diorite - Gabbro (hard)	8	40.8	39.5	39.5	40.0	36.2	46.7	36.0	39.3	23.7	29.5	22.7	25.1	27.5	20.1	26.8	25.0
Volcanic (hard or medium hard)	7			0.4	0.1					4.0	3.2	2.7	3.3	6.3	5.2	3.2	4.9
Trap (≤20% sulphide)	9									2.4	3.5	5.8	3.9	5.4	6.9	3.6	5.2
Quartz (vein or pegmatitic)	10		0.3	0.3	0.2			0.8	0.3								
Feldspar	11			0.4	0.1		0.2		0.0	3.0	2.6	3.7	3.1	3.6	4.3	3.1	3.7
Iron Formation	71	0.4		0.4	0.3	1.2	0.4	0.5	0.7		0.5	0.2	0.2	0.4	0.5	0.2	0.4
Red Jasper - Flint	81																
Orthoquartzite										0.9	0.5	1.7	1.0	4.0	1.8	3.0	3.0
Metasedimentary (hard)																	
Metavolcanic (hard)																	
Total Good Aggregate (%)		96.2	91.1	90.3	92.6	93.9	93.1	91.2	92.7	92.0	94.1	93.1	93.0	97.3	97.5	95.9	96.8
Carbonate (soft, silty, soft, slightly shaley)	35	1.1	3.6	2.9	2.5	1.0	1.2	2.5	1.6	1.6	2.2	1.7	1.8	0.5	0.4	1.3	0.8
Carbonate (soft, pitted)	41	0.0															
Carbonate (deeply weathered, silty, deeply wea	42	0.4			0.1												
Carbonate (sandy, soft)	40		0.3		0.1												
Chert-Cherty Carbonate (<20% leached chert)	26	0.4	2.0	2.0	1.5	3.0	2.6	3.1	2.9	1.8	1.8	1.4	1.7	1.0	0.3	0.2	0.5
Conglomerate-Sandstone-Arkose (brittle)	30	0.0	0.4	1.4	0.6	0.3	1.7	0.2	0.7						0.1	0.4	0.2
Greywacke (brittle)	29	0.0	0.0														
Encrustation	52	0.0	0.5		0.1											0.1	0.0
Gneiss - Amphibolite - Schist (brittle)	25	0.2	0.5	0.1	0.2			0.2	0.1	1.3	0.7	0.5	0.8	0.3	0.1	0.6	0.4
Argillite (medium soft)	34	0.0	0.0														
Granite - Diorite - Gabbro (brittle)	27	0.5	0.1	1.2	0.6	0.0	0.9	1.5	0.8	0.0	0.5	0.8	0.5	0.1	0.3	1.0	0.5
Volcanic (soft)	28		0.0														
Iron Formation	82		0.2		0.1					0.5		0.4	0.3				
Total Fair Aggregate (%)		2.6	7.6	7.6	5.9	4.3	6.4	7.5	6.0	5.3	5.2	4.9	5.1	1.9	1.3	3.6	2.3
Carbonate (shaley, clayey, silty, clayey)	43	0.4	1.0	1.1	0.8	0.6	0.5	0.8	0.6							0.3	0.1
Carbonate (ochreous, sandy, ochreous)	44																
Chert-Cherty Carbonate (>20% leached chert)	45	0.9	0.3	0.2	0.5	1.2		0.6	0.6	1.1	0.6	2.0	1.3	0.9	1.2	0.3	0.8
Conglomerate-Sandstone-Arkose (friable)	46																
Siltstone	56									1.3			0.4				
Cementation (partial)	53																
Gneiss-Amphibolite (friable)	50										0.1		0.0				
Schist (soft)	55																
Granite-Diorite-Gabbro (friable)	51																
Volcanic (very soft, porous)	48																
IRON FORMATION (highly weathered)	84			0.1	0.0												
Total poor Aggregate (%)		1.2	1.3	1.5	1.3	1.8	0.5	1.4	1.3	2.4	0.7	2.0	1.8	0.9	1.2	0.6	0.9
Ochre	60			0.6	0.2												
Shale	61									0.3			0.1				
Clay	62																
Volcanic-Gneiss-Schist (decomposed)	63																
Carbonate (very weak, deeply weathered)	64																
Total Deleterious Aggregate (%)				0.6	0.2					0.3			0.1				
Reported Total Mass Examined (g)		1531.8	523.0	215.7		1536.2	522.5	218.2		1540.2	528.8	214.8		1532.8	525.4	210.4	
% GOOD	X 1 =	96.2	91.1	90.3		93.9	93.1	91.2		92.0	94.1	93.1		97.3	97.5	95.9	
% FAIR	X 3 =	7.7	22.9	22.9		12.9	19.2	22.4		15.9	15.6	14.7		5.6	3.9	10.7	
% POOR	X 6 =	7.5	7.8	8.9		10.8	3.0	8.2		14.2	4.4	12.0		5.2	7.3	3.4	
% DELETERIOUS	X 10 =			5.6						3.4				0.0	0.0	0.0	
PETROGRAPHIC NUMBER		111.4	121.8	127.7		117.6	115.3	121.8		125.5	114.1	**119.8**		108.0	108.7	110.0	
WTD. AVG. PETROGRAPHIC NUMBER			**120.2**				**118.4**				**120.1**				**108.9**		

Laboratory Number		101				101				102				102			
Sample Number		1.15				2.15				1.15				2.15			
Rock Type/Fraction		R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %
Carbonate (hard, silty, hard)	1	14.7	10.0	22.2	15.9	12.3	13.6	19.7	15.3	3.6	3.0	5.6	4.1	6.2	6.2	7.3	6.6
Carbonate (surf. Weath.; silty, surf. Weath.; med. Hard; silty, med. Hard)	20	3.0	3.0	1.7	2.6	1.9	5.1	1.0	2.5	5.8	10.8	16.4	11.0	7.3	9.6	16.9	11.3
Carbonate (sandy, hard or medium hard)	2																
Carbonate (slightly cherty <5%)	21														0.7	0.1	0.2
Marble (hard or medium hard)	23																
Conglomerate-Sandstone-Arkose (hard)	3	2.4	5.4	6.2	4.7	5.1	2.9	5.9	4.7	0.9	2.6	1.0	1.5	1.8	1.4	0.3	1.1
Conglomerate-Sandstone-Arkose (medium har	22																
Greywacke - Argilite (hard or medium hard)	6	25.1	25.1	25.8	25.4	24.1	15.3	24.9	21.7	1.8		1.4	1.1	1.3	7.3	0.1	2.7
Gneiss - Amphibolite - Schist (hard)	4	15.0	12.5	13.6	13.8	16.1	20.2	3.6	13.0								
Quartzite	5	1.3	0.0	0.0	0.4		1.6	1.1	0.9								
Granite - Diorite - Gabbro (hard)	8	32.5	36.7	25.8	31.8	36.1	35.9	34.2	35.4	80.4	67.8	63.8	70.8	66.2	49.0	54.8	57.1
Volcanic (hard or medium hard)	7					1.9	1.4	0.9	1.4	4.6	5.7	5.5	5.3	11.6	15.9	13.0	13.4
Trap (≤20% sulphide)	9	0.6	0.7	0.5	0.6					2.1	8.4	2.8	4.2	4.4	6.7	4.7	5.2
Quartz (vein or pegmatitic)	10		0.8	0.4	0.4		0.5	0.2	0.2	0.3	0.0	1.0	0.5	0.5	1.0	0.4	0.6
Feldspar	11																
Iron Formation	71	1.6	0.7	0.2	0.9	0.7	0.3	1.0	0.7								
Red Jasper - Flint	81		0.3	0.2	0.2		0.3	0.0	0.1								
Orthoquartzite																	
Metasedimentary (hard)																	
Metavolcanic (hard)																	
Total Good Aggregate (%)		96.3	95.3	97.7	96.5	98.3	97.2	92.4	95.9	99.5	98.4	97.5	98.5	99.2	97.7	97.6	98.2
Carbonate (soft, silty, soft, slightly shaley)	35	0.8	2.7	0.7	1.3	0.7	0.8	0.9	0.8								
Carbonate (soft, pitted)	41																
Carbonate (deeply weathered, silty, deeply wea	42																
Carbonate (sandy, soft)	40																
Chert-Cherty Carbonate (<20% leached chert)	26	0.5	0.4	1.7	0.9	0.8	0.5	1.5	1.0			0.8	0.3		1.2	0.0	0.4
Conglomerate-Sandstone-Arkose (brittle)	30																
Greywacke (brittle)	29																
Encrustation	52							0.4	0.1								
Gneiss - Amphibolite - Schist (brittle)	25	1.1			0.4		0.6	1.5	0.7								
Argilite (medium soft)	34																
Granite - Diorite - Gabbro (brittle)	27										0.4	1.4	0.6			0.3	0.1
Volcanic (soft)	28																
Iron Formation	82	*0.2*			*0.1*												
Total Fair Aggregate (%)		2.6	3.1	2.3	2.7	1.5	2.0	4.2	2.6		0.4	2.2	0.9		1.2	0.3	0.5
Carbonate (shaley, clayey, silty, clayey)	43	1.1	0.5	0.0	0.5		0.3		0.1								
Carbonate (ochreous; sandy, ochreous)	44																
Chert-Cherty Carbonate (>20% leached chert)	45		1.1	0.0	0.3	0.2	0.5	3.1	1.3	0.5	1.2	0.1	0.6	0.8	1.1	1.9	1.3
Conglomerate-Sandstone-Arkose (friable)	46																
Siltstone	56																
Cementation (partial)	53																
Gneiss-Amphibolite (friable)	50							0.3	0.1								
Schist (soft)	55																
Granite-Diorite-Gabbro (friable)	51											0.2	0.1			0.2	0.1
Volcanic (very soft, porous)	48																
IRON FORMATION (highly weathered)	84																
Total poor Aggregate (%)		1.1	1.6		0.9	0.2	0.8	3.4	1.5	0.5	1.2	0.3	0.6	0.8	1.1	2.1	1.3
Ochre	60																
Shale	61																
Clay	62																
Volcanic-Gneiss-Schist (decomposed)	63																
Carbonate (very weak, deeply weathered)	64																
Total Deleterious Aggregate (%)																	
Reported Total Mass Examined (g)		1539.2	534.3	212.8		1531.9	519.6	219.0		1534.1	520.1	214.2		1532.0	521.6	209.8	
% GOOD	X 1 =	96.3	95.3	97.7		98.3	97.2	92.4		99.5	98.4	97.5		99.2	97.7	97.6	
% FAIR	X 3 =	7.8	9.3	7.0		4.4	5.9	12.6		0.0	1.2	6.6		0.0	3.6	0.9	
% POOR	X 6 =	6.9	9.7			1.4	5.0	20.3		2.8	7.5	1.7		4.9	6.6	12.6	
% DELETERIOUS	X 10 =										0.0	0.0					
PETROGRAPHIC NUMBER		110.9	114.3	104.7		104.1	108.1	125.3		102.3	107.0	105.8		104.0	107.9	111.1	
WTD. AVG. PETROGRAPHIC NUMBER		**109.7**				**112.7**				**104.9**				**107.7**			

Laboratory Number		109				109				133				133			
Sample Number		1.15				2.15				1.15				2.15			
Rock Type/Fraction		R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %
Carbonate (hard, silty, hard)	1	5.1	10.5	10.8	8.7	9.1	12.8	5.7	9.0	2.9	1.8	4.0	3.0	4.6	2.3	5.6	4.6
Carbonate (surf. Weath., silty, surf. Weath.; med. Hard, silty, med. Hard)	20	8.0	8.1	8.6	8.3	7.8	4.2	10.8	7.8	6.7	9.3	11.7	9.2	13.9	5.5	10.1	10.1
Carbonate (sandy, hard or medium hard)	2																
Carbonate (slightly cherty <5%)	21	0.6	1.0	0.0	0.5	0.3	2.0	2.1	1.5					1.2	0.8	1.0	1.0
Marble (hard or medium hard)	23																
Conglomerate-Sandstone-Arkose (hard)	3	24.7	16.3	11.6	17.6	30.2	25.7	22.7	26.2	3.6	2.1	3.6	3.2	2.2	2.0	3.2	2.5
Conglomerate-Sandstone-Arkose (medium har	22	10.4	2.8	9.8	7.9	2.9	3.2	7.6	4.6								
Greywacke - Argillite (hard or medium hard)	6									24.0	23.7	28.9	25.6	20.3	25.8	21.9	22.5
Gneiss - Amphibolite - Schist (hard)	4	3.0	6.5	0.9	3.3	5.5	5.4	5.8	5.6	29.7	20.2	14.8	21.7	21.4	17.0	21.1	20.0
Quartzite	5	3.3	1.1	1.7	2.1	3.1	2.8	0.5	2.1		0.3		0.1				
Granite - Diorite - Gabbro (hard)	8	38.4	46.5	41.2	41.8	33.3	36.3	33.6	34.3	16.7	29.4	22.4	22.5	21.6	27.3	17.6	21.9
Volcanic (hard or medium hard)	7	3.0	1.1	0.6	1.6	2.0	1.0	1.0	1.3					0.8			0.3
Trap (≤20% sulphide)	9	0.4	0.0	0.8	0.4	0.3			0.1	11.3	7.5	5.4	8.1	9.1	13.0	10.4	10.8
Quartz (vein or pegmatitic)	10			0.5	0.2			0.3	0.1								
Feldspar	11																
Iron Formation	71																
Red Jasper - Flint	81																
Orthoquartzite																	
Metasedimentary (hard)																	
Metavolcanic (hard)																	
Total Good Aggregate (%)		96.9	93.9	86.5	92.4	94.4	93.4	90.1	92.6	94.9	94.3	90.9	93.4	95.0	93.7	92.0	93.6
Carbonate (soft, silty, soft; slightly shaley)	35									1.6	1.4	2.1	1.7	1.3	3.5	1.6	2.1
Carbonate (soft, pitted)	41																
Carbonate (deeply weathered, silty, deeply wea	42	0.5	0.9	1.8	1.1	0.9	2.2	3.3	2.1								
Carbonate (sandy, soft)	40																
Chert-Cherty Carbonate (<20% leached chert)	26	2.0	1.2	4.3	2.6	0.7	1.5	1.6	1.2	1.9	2.4	0.7	1.6	1.6	1.3	2.2	1.7
Conglomerate-Sandstone-Arkose (brittle)	30	0.3	0.8	2.8	1.3	0.4	1.0	1.3	0.9						0.4		0.1
Greywacke (brittle)	29																
Encrustation	52									0.9		1.5	0.8	0.3			0.1
Gneiss - Amphibolite - Schist (brittle)	25					0.3			0.1		0.5	1.2	0.6	0.7	0.6	1.7	1.0
Argillite (medium soft)	34																
Granite - Diorite - Gabbro (brittle)	27	0.3	1.2	3.5	1.7	0.5	0.7	2.9	1.4			0.2	0.1				
Volcanic (soft)	28																
Iron Formation	82																
Total Fair Aggregate (%)		3.1	4.2	12.3	6.7	2.9	5.4	9.2	5.8	4.4	4.2	5.8	4.8	3.9	5.8	5.5	5.0
Carbonate (shaley, clayey, silty, clayey)	43		0.4	0.0	0.1											0.3	0.1
Carbonate (ochreous, sandy, ochreous)	44																
Chert-Cherty Carbonate (>20% leached chert)	45		1.2	0.4	0.5	2.7	1.2	0.3	1.4	0.7	1.2	1.9	1.2	1.1	0.5	2.2	1.3
Conglomerate-Sandstone-Arkose (friable)	46		0.3	0.4	0.2			0.4	0.1								
Siltstone	56										0.3	1.0	0.4				
Cementation (partial)	53																
Gneiss-Amphibolite (friable)	50											0.4	0.1				
Schist (soft)	55																
Granite-Diorite-Gabbro (friable)	51			0.3	0.1												
Volcanic (very soft, porous)	48																
IRON FORMATION (highly weathered)	84																
Total poor Aggregate (%)			1.9	1.2	1.0	2.7	1.2	0.7	1.6	0.7	1.4	3.3	1.8	1.1	0.5	2.5	1.4
Ochre	60																
Shale	61																
Clay	62																
Volcanic-Gneiss-Schist (decomposed)	63																
Carbonate (very weak, deeply weathered)	64																
Total Deleterious Aggregate (%)																	
Reported Total Mass Examined (g)		1539.1	529.3	214.0		1532.9	537.4	215.9		1541.1	519.5	222.4		1534.1	522.3	217.1	
% GOOD	X 1 =	96.9	93.9	86.5		94.4	93.4	90.1		94.9	94.3	90.9		95.0	93.7	92.0	
% FAIR	X 3 =	9.3	12.5	37.0		8.6	16.2	27.5		13.1	12.7	17.3		11.7	17.5	16.4	
% POOR	X 6 =		11.4	7.0		16.3	7.1	4.2		4.1	8.5	20.0		6.6	2.8	14.9	
% DELETERIOUS	X 10 =																
PETROGRAPHIC NUMBER		106.2	117.9	130.5		119.3	116.8	121.8		112.2	115.6	128.1		113.2	114.0	123.4	
WTD. AVG. PETROGRAPHIC NUMBER		**118.2**				**119.4**				**118.8**				**117.0**			

Laboratory Number		152				152				166				166			
Sample Number		1.15				2.15				1.15				2.15			
Rock Type/Fraction		R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %
Carbonate (hard, silty, hard)	1	7.5	14.5	15.2	12.3	11.0	9.2	17.0	12.5	4.2	3.9	4.8	4.3	2.2	3.3	2.6	2.7
Carbonate (surf. Weath., silty, surf. Weath., med. Hard, silty, med. Hard)	20	4.6	3.6	2.1	3.4	2.7	1.9	4.8	3.2	6.5	5.4	15.1	9.2	6.8	8.8	11.0	8.9
Carbonate (sandy, hard or medium hard)	2					2.1			0.7								
Carbonate (slightly cherty <5%)	21									0.3	1.5	0.5	0.7	0.4	1.1	0.4	0.6
Marble (hard or medium hard)	23																
Conglomerate-Sandstone-Arkose (hard)	3	28.2	23.2	26.5	26.1	24.1	24.5	29.2	26.0	1.5	1.3	2.1	1.7	0.6	1.2	2.0	1.3
Conglomerate-Sandstone-Arkose (medium har	22	1.5	0.0	1.1	0.9	1.2	1.4	0.5	1.0	0.6	1.2	0.7	0.8	1.1	1.4	2.0	1.5
Greywacke - Argillite (hard or medium hard)	6						0.2		0.1	25.1	27.7	30.1	27.6	25.3	19.3	24.5	23.2
Gneiss - Amphibolite - Schist (hard)	4	24.6	10.2	9.8	15.1	22.8	13.1	11.8	16.0	31.3	29.4	18.1	26.1	31.3	30.5	21.3	27.6
Quartzite	5	1.7	1.3	2.5	1.9	0.3	2.1	3.1	1.8	0.3	0.3		0.2	0.0	0.0	0.8	0.3
Granite - Diorite - Gabbro (hard)	8	26.4	41.2	30.2	32.2	32.2	41.5	28.2	33.6	19.8	20.3	13.7	17.8	19.6	20.8	15.8	18.6
Volcanic (hard or medium hard)	7													0.0	0.0	0.0	0.0
Trap (≤20% sulphide)	9	1.1	1.0	1.7	1.3	0.5	1.7	0.5	0.9	2.9	3.7	4.7	3.8	6.8	4.8	8.2	6.7
Quartz (vein or pegmatitic)	10																
Feldspar	11																
Iron Formation	11	1.2	0.8	0.7	0.9	0.5	1.3	1.1	1.0								
Red Jasper - Flint	81																
Orthoquartzite																	
Metasedimentary (hard)																	
Metavolcanic (hard)																	
Total Good Aggregate (%)		96.8	95.9	89.9	94.1	97.4	96.9	96.2	96.8	92.5	94.7	89.8	92.2	94.2	91.1	88.4	91.3
Carbonate (soft, silty, soft, slightly shaley)	35	0.3	0.7	0.8	0.6					2.6	1.8	4.0	2.8	3.3	3.4	3.8	3.5
Carbonate (soft, pitted)	41																
Carbonate (deeply weathered, silty, deeply wea	42																
Carbonate (sandy, soft)	40																
Chert-Cherty Carbonate (<20% leached chert)	26	1.3	0.5	0.7	0.8	1.0	0.6	0.4	0.7	2.7	0.9	1.7	1.8	1.4	2.7	1.9	2.0
Conglomerate-Sandstone-Arkose (brittle)	30	0.1	0.0	0.8	0.3			0.1	0.0							0.7	0.2
Greywacke (brittle)	29																
Encrustation	52			0.3	0.1			0.5	0.2	0.6	1.1	1.0	0.9			0.4	0.1
Gneiss - Amphibolite - Schist (brittle)	25	0.0	0.1	0.4	0.2			0.3	0.1	0.1	0.7	1.7	0.9	0.1	1.0	1.8	1.0
Argillite (medium soft)	34																
Granite - Diorite - Gabbro (brittle)	27	0.0	0.3	1.5	0.6		0.1	0.5	0.2	0.0	0.1	0.7	0.3	0.0	0.2	1.1	0.5
Volcanic (soft)	28																
Iron Formation	82							0.0	0.0								
Total Fair Aggregate (%)		1.7	1.6	4.4	2.6	1.0	0.7	1.9	1.2	6.0	4.6	9.1	6.7	4.8	7.4	9.8	7.3
Carbonate (shaley, clayey, silty, clayey)	43	1.0	1.8	3.3	2.1	1.4	1.3	1.3	1.4					0.4		0.4	0.3
Carbonate (ochreous, sandy, ochreous)	44																
Chert-Cherty Carbonate (>20% leached chert)	45		0.3	2.0	0.8	0.2	1.0	0.6	0.6	1.5	0.8	0.7	1.0	0.6	1.5	1.1	1.0
Conglomerate-Sandstone-Arkose (friable)	46																
Siltstone	56															0.2	0.1
Cementation (partial)	53																
Gneiss-Amphibolite (friable)	50											0.2	0.1			0.0	0.0
Schist (soft)	55																
Granite-Diorite-Gabbro (friable)	51											0.1	0.0				
Volcanic (very soft, porous)	48																
IRON FORMATION (highly weathered)	84																
Total poor Aggregate (%)		1.0	2.2	5.3	2.9	1.6	2.3	1.9	1.9	1.5	0.8	1.1	1.1	1.0	1.5	1.8	1.4
Ochre	60																
Shale	61	0.5	0.3	0.4	0.4												
Clay	62																
Volcanic-Gneiss-Schist (decomposed)	63																
Carbonate (very weak, deeply weathered)	64																
Total Deleterious Aggregate (%)		0.5	0.3	0.4	0.4												
Reported Total Mass Examined (g)		1523.4	519.1	211.9		1529.1	526.1	206.0		1538.6	528.6	214.6		1537.3	527.6	218.1	
% GOOD	X 1 =	96.8	95.9	89.9		97.4	96.9	96.2		92.5	94.7	89.8		94.2	91.1	88.4	
% FAIR	X 3 =	5.0	4.8	13.3		3.0	2.2	5.7		18.1	13.7	27.4		14.5	22.1	29.3	
% POOR	X 6 =	6.3	13.1	32.0		9.8	13.9	11.7		8.8	4.5	6.4		5.7	8.9	10.7	
% DELETERIOUS	X 10 =	4.7	3.1	3.8													
PETROGRAPHIC NUMBER		112.8	116.9	138.9		110.2	113.1	113.5		119.3	112.9	123.6		114.5	122.1	138.5	
WTD. AVG. PETROGRAPHIC NUMBER		**123.3**				**112.2**				**118.9**				**121.7**			

Laboratory Number		103				103				260				260			
Sample Number		1.15				2.15				1.15				2.15			
Rock Type/Fraction		R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %
Carbonate (hard, silty, hard)	1	45.3	43.8	50.8	46.8	44.6	41.4	44.8	43.7	10.6	10.8	19.7	13.9	9.4	12.0	21.5	14.4
Carbonate (surf. Weath., silty, surf. Weath., med. Hard, silty, med. Hard)	20	0.5	0.3	2.8	1.2	1.0	3.1	5.7	3.3	2.5	2.1		1.5	2.6	2.6	1.0	2.1
Carbonate (sandy, hard or medium hard)	2																
Carbonate (slightly cherty <5%)	21	3.2	2.1	2.6	2.6	2.7	2.5	3.4	2.9								
Marble (hard or medium hard)	23	0.5			0.2												
Conglomerate-Sandstone-Arkose (hard)	3									1.0	1.2	2.1	1.5	1.7	2.7	1.7	2.0
Conglomerate-Sandstone-Arkose (medium har	22																
Greywacke - Argillite (hard or medium hard)	6																
Gneiss - Amphibolite - Schist (hard)	4		1.4	1.2	0.8	1.2	1.7		0.9		2.4		0.7				
Quartzite	5	0.4	0.0	0.5	0.3	0.4		1.1	0.5	0.3		0.7	0.4				
Granite - Diorite - Gabbro (hard)	8	43.7	46.5	33.9	41.1	44.4	45.1	37.3	42.1	48.0	48.6	39.0	45.0	45.9	46.7	34.9	43.7
Volcanic (hard or medium hard)	7																
Trap (≤20% sulphide)	9	5.2	3.5	3.3	4.0	4.6	4.6	3.4	4.2	37.7	32.6	35.9	35.5	34.5	34.2	35.9	35.3
Quartz (vein or pegmatitic)	10			0.2	0.1												
Feldspar	11																
Iron Formation	71																
Red Jasper - Flint	81																
Orthoquartzite																	
Metasedimentary (hard)																	
Metavolcanic (hard)																	
Total Good Aggregate (%)		98.8	97.5	95.3	97.2	98.7	98.4	95.8	97.6	100.0	97.7	97.5	98.5	98.1	98.2	99.0	98.5
Carbonate (soft, silty, soft, slightly shaley)	35		0.8	0.3	0.4	0.3	0.6	0.6	0.5		0.0	1.5	0.5				
Carbonate (soft, pitted)	41										0.0	0.3	0.1				
Carbonate (deeply weathered, silty, deeply wea	42														0.3	0.0	0.1
Carbonate (sandy, soft)	40										0.3	0.0	0.1				
Chert-Cherty Carbonate (<20% leached chert)	26	0.8	0.4	0.4	0.6	0.4	0.4	0.5	0.5		1.9	0.7	0.8	1.6	1.0	0.8	1.1
Conglomerate-Sandstone-Arkose (brittle)	30													0.3			0.1
Greywacke (brittle)	29																
Encrustation	52																
Gneiss - Amphibolite - Schist (brittle)	25																
Argillite (medium soft)	34																
Granite - Diorite - Gabbro (brittle)	27		0.3	1.6	0.7			1.0	0.4								
Volcanic (soft)	28																
Iron Formation	82																
Total Fair Aggregate (%)		0.8	1.6	2.3	1.6	0.7	1.0	2.1	1.3		2.3	2.5	1.5	1.9	1.3	0.8	1.3
Carbonate (shaley, clayey, silty, clayey)	43			0.5	0.2												
Carbonate (ochreous, sandy, ochreous)	44																
Chert-Cherty Carbonate (>20% leached chert)	45	0.4	0.7		0.4	0.5	0.5	0.8	0.6						0.4	0.3	0.2
Conglomerate-Sandstone-Arkose (friable)	46																
Siltstone	56																
Cementation (partial)	53																
Gneiss-Amphibolite (friable)	50																
Schist (soft)	55																
Granite-Diorite-Gabbro (friable)	51		0.2	1.9	0.7		0.1	1.3	0.5								
Volcanic (very soft, porous)	48																
IRON FORMATION (highly weathered)	84																
Total poor Aggregate (%)		0.4	0.9	2.3	1.2	0.5	0.6	2.1	1.1						0.4	0.3	0.2
Ochre	60			0.1	0.0												
Shale	61																
Clay	62																
Volcanic-Gneiss-Schist (decomposed)	63																
Carbonate (very weak, deeply weathered)	64																
Total Deleterious Aggregate (%)				0.1	0.0												
Reported Total Mass Examined (g)		1528.2	526.3	215.0		1528.5	516.5	213.2		1546.7	492.9	214.7		1532.4	525.9	213.1	
% GOOD	X 1 =	98.8	97.5	95.3		98.7	98.4	95.8		100.0	97.7	97.5		98.1	98.2	99.0	
% FAIR	X 3 =	2.4	4.8	7.0		2.1	3.0	6.3			6.8	7.4		5.6	4.0	2.3	
% POOR	X 6 =	2.6	5.4	14.0		3.3	3.7	12.4							2.6	1.7	
% DELETERIOUS	X 10 =	0.0	0.0	0.9													
PETROGRAPHIC NUMBER		103.8	107.7	117.1		104.1	105.1	114.5		100.0	104.5	104.9		103.7	104.8	102.9	
WTD. AVG. PETROGRAPHIC NUMBER			**109.6**				**108.1**				**103.1**				**103.8**		

Laboratory Number		293				293				316				316			
Sample Number		1.15				2.15				1.15				2.15			
Rock Type/Fraction		R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %
Carbonate (hard, silty, hard)	1	6.4	10.6	20.0	12.4	10.8	10.6	17.1	12.9	3.7	4.5	6.0	4.7	4.0	5.2	5.8	5.0
Carbonate (surf. Weath., silty, surf. Weath., med. Hard, silty, med. Hard)	20	0.8	0.8	0.7	0.8	1.5	0.5	0.7	0.9	7.5	10.8	16.4	11.6	8.2	8.4	13.6	10.2
Carbonate (sandy, hard or medium hard)	2	0.3	0.2	0.3	0.3	0.9	0.5	0.8	0.7								
Carbonate (slightly cherty, <5%)	21	1.3	0.2		0.5	0.8	0.3		0.4	0.2	1.5	0.7	0.8	0.5	1.0	1.1	0.9
Marble (hard or medium hard)	23				0.0				0.0								
Conglomerate-Sandstone-Arkose (hard)	3	2.5	0.8	1.9	1.8	2.9	1.0	0.3	1.4	5.2	3.1	1.8	3.4	2.7	2.9	2.5	2.7
Conglomerate-Sandstone-Arkose (medium har	22			0.2	0.1				0.0	1.0	2.1	2.9	2.0	1.5	0.8	0.9	1.1
Greywacke - Argillite (hard or medium hard)	6	30.2	22.3	31.3	28.2	29.3	26.9	32.1	29.6	27.0	29.6	26.9	27.8	31.3	22.1	27.3	27.1
Gneiss - Amphibolite - Schist (hard)	4	29.3	27.0	16.2	24.0	17.1	20.2	17.9	18.3	4.3	6.3	9.3	6.6	11.5	15.4	9.4	12.0
Quartzite	5			0.2	0.1				0.0								
Granite - Diorite - Gabbro (hard)	8	16.3	25.4	14.4	18.4	24.8	27.0	17.4	22.9	38.2	32.0	27.3	32.5	29.0	33.3	26.3	29.4
Volcanic (hard or medium hard)	7	4.0	1.0	1.6	2.3	3.4	2.9	1.1	2.4	0.7			0.2				
Trap (≤20% sulphide)	9								0.0	7.2	6.9	3.5	5.8	3.8	3.7	3.5	3.6
Quartz (vein or pegmatitic)	10									0.3	0.7	0.6	0.5	0.7	0.9	0.0	0.5
Feldspar	11		0.2	0.4	0.2			0.2	0.1								
Iron Formation	71																
Red Jasper - Flint	81																
Orthoquartzite																	
Metasedimentary (hard)																	
Metavolcanic (hard)																	
Total Good Aggregate (%)		**90.6**	**88.7**	**87.3**	**88.9**	**91.4**	**89.9**	**87.8**	**89.7**	**95.2**	**97.4**	**95.4**	**95.9**	**93.2**	**93.7**	**90.4**	**92.4**
Carbonate (soft, silty, soft, slightly shaley)	35	0.8		1.8	0.9	1.0	0.5	0.6	0.7	0.6	0.2	0.9	0.6	0.7	0.7	1.4	1.0
Carbonate (soft, pitted)	41				0.0												
Carbonate (deeply weathered, silty, deeply we	42		0.5		0.2												
Carbonate (sandy, soft)	40				0.0												
Chert-Cherty Carbonate (<20% leached chert)	26	3.5	5.1	3.6	4.0	2.6	1.9	2.8	2.5	0.8	1.1	0.6	0.8	1.1	0.8	0.9	0.9
Conglomerate-Sandstone-Arkose (brittle)	30				0.0		0.6		0.2	0.3	0.5	0.1	0.3	1.0	0.9	0.6	0.8
Greywacke (brittle)	29			0.4	0.1			0.7	0.2	0.0	0.0	0.0	0.0				
Encrustation	52				0.0					0.3	0.0	0.2	0.2	0.8	0.6	1.1	0.8
Gneiss - Amphibolite - Schist (brittle)	25	3.2	1.4	1.2	2.0	2.3	1.5	5.0	3.0	0.4	0.0	0.7	0.4	0.7	1.0	2.0	1.3
Argillite (medium soft)	34	0.3	0.6	2.7	1.2	1.6	1.4	0.8	1.3	0.0	0.0	0.0	0.0				
Granite - Diorite - Gabbro (brittle)	27	0.4	1.4	1.5	1.1	0.4	1.5	0.5	0.8	1.3	0.3	1.9	1.2	1.4	2.3	3.6	2.4
Volcanic (soft)	28		0.6		0.2												
Iron Formation	82																
Total Fair Aggregate (%)		**8.3**	**9.7**	**11.1**	**9.7**	**8.0**	**7.4**	**10.4**	**8.7**	**3.7**	**2.0**	**4.6**	**3.5**	**5.7**	**6.3**	**9.6**	**7.2**
Carbonate (shaley, clayey, silty, clayey)	43	0.4		0.5	0.3		0.7	0.5	0.4					0.2			0.1
Carbonate (ochreous; sandy, ochreous)	44																
Chert-Cherty Carbonate (<20% leached chert)	45	0.7	1.1	0.8	0.9	0.3	1.2	0.9	0.8	0.6	0.4		0.3	0.7			0.3
Conglomerate-Sandstone-Arkose (friable)	46																
Siltstone	56									0.1				0.2			0.1
Cementation (partial)	53																
Gneiss-Amphibolite (friable)	50		0.5	0.2	0.2	0.3	0.8	0.3	0.5								
Schist (soft)	55																
Granite-Diorite-Gabbro (friable)	51							0.1	0.0	0.3	0.2		0.2				
Volcanic (very soft, porous)	48			0.1													
IRON FORMATION (highly weathered)	84																
Total poor Aggregate (%)		**1.1**	**1.6**	**1.7**	**1.5**	**0.6**	**2.7**	**1.8**	**1.7**	**1.1**	**0.6**		**0.6**	**1.1**			**0.4**
Ochre	60																
Shale	61																
Clay	62																
Volcanic-Gneiss-Schist (decomposed)	63																
Carbonate (very weak, deeply weathered)	64																
Total Deleterious Aggregate (%)																	
Reported Total Mass Examined (g)		**1526.5**	**530.0**	**216.0**		**1534.4**	**519.4**	**214.1**		**1535.7**	**528.9**	**205.7**		**1537.7**	**549.5**	**224.8**	
% GOOD	X 1 =	90.6	88.7	87.3		91.4	89.9	87.8		95.2	97.4	95.4		93.2	93.7	90.4	
% FAIR	X 3 =	24.9	29.1	33.3		24.0	22.2	31.2		11.2	6.1	13.7		17.0	18.9	29.7	
% POOR	X 6 =	6.6	9.6	10.2		3.6	16.2	10.8		6.5	3.5			6.6			
% DELETERIOUS	X 10 =																
PETROGRAPHIC NUMBER		122.0	127.0	131.0		119.0	128.0	130.0		112.9	107.0	109.1		116.8	112.6	119.1	
WTD. AVG. PETROGRAPHIC NUMBER		**127.0**				**126.0**				**109.8**				**116.4**			

Laboratory Number		350				350				351				351			
Sample Number		1.15				2.15				1.15				2.15			
Rock Type/Fraction		R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %
Carbonate (hard, silty, hard)	1	11.3	12.4	20.1	**12.4**	11.0	12.8	17.6	**12.0**	11.9	8.8	19.0	13.4	9.4	12.0	18.0	13.2
Carbonate (surf. Weath., silty, surf. Weath., med. Hard, silty, med. Hard)	20	2.3	1.2	1.7	**2.0**	2.9	3.7	1.1	**2.9**	3.2	6.8	2.2	3.9	2.1	5.1	2.6	3.2
Carbonate (sandy, hard or medium hard)	2		0.0	1.3	**0.1**	0.0	1.8	1.6	**0.6**								
Carbonate (slightly cherty, <5%)	21	0.5	1.4	1.7	**0.8**	1.9		4.1	**1.7**	0.8	1.5	0.5	0.9	1.4	0.4	0.6	0.8
Marble (hard or medium hard)	23																
Conglomerate-Sandstone-Arkose (hard)	3	2.1		1.9	**1.6**	3.9	3.9	2.9	**3.8**	1.9	1.7		1.2	0.6	1.1	0.7	0.8
Conglomerate-Sandstone-Arkose (medium har	22																
Greywacke - Argillite (hard or medium hard)	6	27.4	22.0	29.3	**26.2**	24.0	26.6	25.3	**24.7**	2.5	4.5	3.6	3.5	3.5	0.7	0.8	1.7
Gneiss - Amphibolite - Schist (hard)	4	31.9	32.6	23.4	**31.3**	31.0	29.2	24.0	**30.0**	42.2	34.6	40.3	39.3	45.1	43.5	37.7	42.1
Quartzite	5	1.1			**0.7**		0.9	0.6	**0.3**								
Granite - Diorite - Gabbro (hard)	8	17.2	20.5	14.8	**17.8**	19.4	11.9	14.6	**17.2**	15.4	7.4	10.3	11.2	11.2	9.1	6.3	8.8
Volcanic (hard or medium hard)	7	0.8	5.3	2.2	**1.9**	2.7	4.3		**2.8**	0.3			0.1	0.3			0.1
Trap (≤20% sulphide)	9									17.3	26.4	21.8	21.6	20.0	23.1	29.2	23.8
Quartz (vein or pegmatitic)	10									0.2	0.7	0.4	0.4	0.2		0.8	0.3
Feldspar	11																
Iron Formation	71					2.7											
Red Jasper - Flint	81																
Orthoquartzite																	
Metasedimentary (hard)																	
Metavolcanic (hard)																	
Total Good Aggregate (%)		**94.6**	**95.4**	**95.5**	***94.9***	**96.8**	**95.1**	**91.7**	***95.9***	**95.7**	**92.4**	**98.1**	**95.5**	**93.8**	**95.1**	**95.7**	**94.9**
Carbonate (soft, silty, soft, slightly shaley)	35	1.5		0.3	**1.1**	1.0	0.3	1.2	**0.8**	1.1	3.6	1.1	1.9	1.3	1.7	1.4	1.4
Carbonate (soft, pitted)	41						0.3		**0.1**								
Carbonate (deeply weathered, silty, deeply wea	42																
Carbonate (sandy, soft)	40																
Chert-Cherty Carbonate (<20% leached chert)	26	2.9	3.4	0.9	**2.8**	1.6	2.0	2.3	**1.8**	1.1	1.1	0.5	0.9	2.1	1.5	0.7	1.4
Conglomerate-Sandstone-Arkose (brittle)	30			0.4													
Greywacke (brittle)	29																
Encrustation	52													0.3		0.4	0.2
Gneiss - Amphibolite - Schist (brittle)	25	0.4		1.5	**0.4**	0.4	2.0	2.3	**0.9**	0.8	0.8	0.0	0.5	1.0			0.3
Argillite (medium soft)	34																
Granite - Diorite - Gabbro (brittle)	27	0.3		1.1	**0.3**												
Volcanic (soft)	28																
Iron Formation	82																
Total Fair Aggregate (%)		**5.1**	**3.4**	**4.2**	***4.6***	**2.9**	**4.6**	**8.3**	***3.8***	**3.1**	**5.6**	**1.6**	**3.3**	**4.7**	**3.2**	**2.5**	**3.5**
Carbonate (shaley, clayey, silty, clayey)	43	0.3		0.2	**0.2**					0.9	0.5	0.4	0.6	0.6	0.9	0.8	0.8
Carbonate (ochreous, sandy, ochreous)	44																
Chert-Cherty Carbonate (>20% leached chert)	45		1.2		**0.3**						1.2	0.0	0.3	0.9	0.7	1.0	0.9
Conglomerate-Sandstone-Arkose (friable)	46																
Siltstone	56																
Cementation (partial)	53									0.3	0.3	0.0	0.2				
Gneiss-Amphibolite (friable)	50					0.3	0.4		**0.3**								
Schist (soft)	55																
Granite-Diorite-Gabbro (friable)	51																
Volcanic (very soft, porous)	48																
IRON FORMATION (highly weathered)	84																
Total poor Aggregate (%)		**0.3**	**1.2**	**0.2**	***0.5***	**0.3**	**0.4**	**0.0**	***0.3***	**1.2**	**2.0**	**0.4**	**1.2**	**1.5**	**1.7**	**1.8**	**1.7**
Ochre	60																
Shale	61																
Clay	62																
Volcanic-Gneiss-Schist (decomposed)	63																
Carbonate (very weak, deeply weathered)	64																
Total Deleterious Aggregate (%)																	
Reported Total Mass Examined (g)		**1530.4**	**529.3**	**212.5**		**1532.7**	**525.9**	**206.1**		**1536.1**	**521.7**	**218.2**		**1534.9**	**522.9**	**212.0**	
% GOOD	x 1 =	94.6	95.4	95.5		96.8	95.1	91.7		95.7	92.4	98.1		93.8	95.1	95.7	
% FAIR	x 3 =	15.3	10.2	12.7		8.7	13.7	24.9		9.3	16.7	4.7		14.0	9.6	7.5	
% POOR	x 6 =	1.9	7.3			1.9	2.2			7.3	12.2	2.2		9.1	10.0	11.0	
% DELETERIOUS	x 10 =																
PETROGRAPHIC NUMBER		111.8	112.8	108.2		107.4	110.9	116.6		112.3	121.3	104.9		116.9	114.7	114.2	
WTD. AVG. PETROGRAPHIC NUMBER		**111.8**				**109.0**				**112.4**				**115.3**			

Laboratory Number		MTO Petrographer				MTO Petrographer			
Sample Number		1.15				2.15			
Rock Type/Fraction		R13.2	R9.5	R4.75	Wt. %	R13.2	R9.5	R4.75	Wt. %
Carbonate (hard, silty, hard)	1	0.3			0.1				
Carbonate (surf. Weath., silty, surf. Weath.; med. Hard, silty, med. Hard)	20	7.1	17.3	14.2	12.7	12.1	14.8	16.6	14.5
Carbonate (sandy, hard or medium hard)	2								
Carbonate (slightly cherty <5%)	21	0.4			0.1				
Marble (hard or medium hard)	23								
Conglomerate-Sandstone-Arkose (hard)	3	1.4	0.7	3.0	1.8	2.9	2.1	2.5	2.5
Conglomerate-Sandstone-Arkose (medium har	22								
Greywacke - Argillite (hard or medium hard)	6	31.7	16.3	11.2	19.9	22.5	10.5	13.0	15.6
Gneiss - Amphibolite - Schist (hard)	4	19.0	15.9	9.9	14.9	17.1	15.1	5.7	12.5
Quartzite	5		0.3	0.0	0.1	0.9	0.9	0.0	0.6
Granite - Diorite - Gabbro (hard)	8	22.2	19.7	25.0	22.4	25.2	25.5	28.6	26.5
Volcanic (hard or medium hard)	7	0.3	0.0	0.1	0.1	0.8	1.6	1.1	1.1
Trap (≤20% sulphide)	9	2.0	14.5	26.6	14.3	8.5	17.5	18.3	14.7
Quartz (vein or pegmatitic)	10		0.4	0.5	0.3		0.7	0.9	0.5
Feldspar	11	1.2			0.4				
Iron Formation	71								
Red Jasper - Flint	81								
Orthoquartzite									
Metasedimentary (hard)									
Metavolcanic (hard)									
Total Good Aggregate (%)		**85.5**	**85.0**	**90.5**	**87.1**	**90.0**	**88.8**	**86.6**	**88.5**
Carbonate (soft, silty, soft, slightly shaley)	35	3.0	0.9	2.8	2.3	0.4	0.7	2.7	1.3
Carbonate (soft, pitted)	41	0.2	0.2	0.1	0.2	0.3	0.6		0.3
Carbonate (deeply weathered, silty, deeply wea	42	0.9			0.3				
Carbonate (sandy, soft)	40								
Chert-Cherty Carbonate (<20% leached chert)	26	2.7	1.6		1.4	0.9	2.4	1.6	1.6
Conglomerate-Sandstone-Arkose (brittle)	30	0.4		0.3	0.2			0.4	0.1
Greywacke (brittle)	29								
Encrustation	52					0.4			0.1
Gneiss - Amphibolite - Schist (brittle)	25	3.4	5.0	2.4	3.6	4.6	5.2	2.8	4.1
Argillite (medium soft)	34								
Granite - Diorite - Gabbro (brittle)	27	2.8	3.4	1.7	2.6	0.3	0.8	1.6	0.9
Volcanic (soft)	28							0.4	0.1
Iron Formation	82								
Total Fair Aggregate (%)		**13.3**	**11.1**	**7.4**	**10.6**	**6.9**	**9.6**	**9.5**	**8.6**
Carbonate (shaley, clayey, silty, clayey)	43								
Carbonate (ochreous, sandy, ochreous)	44								
Chert-Cherty Carbonate (>20% leached chert)	45	0.2		1.7	0.7	1.0		1.5	0.9
Conglomerate-Sandstone-Arkose (friable)	46								
Siltstone	56								
Cementation (partial)	53								
Gneiss-Amphibolite (friable)	50	0.9	1.6	0.3	0.9	0.7	1.6	0.4	0.9
Schist (soft)	55								
Granite-Diorite-Gabbro (friable)	51		0.6	0.1	0.2	0.7		1.8	0.9
Volcanic (very soft, porous)	48		1.7		0.5	0.3			0.1
IRON FORMATION (highly weathered)	84								
Total poor Aggregate (%)		**1.2**	**3.8**	**2.1**	**2.3**	**2.7**	**1.6**	**3.7**	**2.7**
Ochre	60								
Shale	61					0.4			0.1
Clay	62								
Volcanic-Gneiss-Schist (decomposed)	63								
Carbonate (very weak, deeply weathered)	64							0.1	0.0
Total Deleterious Aggregate (%)						**0.4**		**0.1**	**0.2**
Reported Total Mass Examined (g)		**1533.8**	**512.8**	**216.9**		**1536.3**	**531.1**	**215.4**	
% GOOD	x 1 =	85.5	85.0	90.5		90.0	88.8	86.6	
% FAIR	x 3 =	39.9	33.3	22.3		20.7	28.9	28.6	
% POOR	x 6 =	7.0	23.0	12.4		16.3	9.7	22.3	
% DELETERIOUS	x 10 =					3.6		1.4	
PETROGRAPHIC NUMBER		132.4	141.4	125.2		130.7	127.3	138.9	
WTD. AVG. PETROGRAPHIC NUMBER		**132.6**				**132.5**			

Appendix E2: Petrographic Results of Fine Aggregate

Laboratory Number	5	5	14	14	15	15	27	27	47	47	80	80
Sample Number	1.15	2.15	1.15	2.15	1.15	2.15	1.15	2.15	1.15	2.15	1.15	2.15
Silicate (4.75-2.36 mm)	13.0	20.0	18.0	18.0	35.0	31.0	21.0	23.5	20.5	23.5	24.0	19.5
Silicate (2.36-1.18 mm)	18.2	16.0	24.6	24.0	35.0	31.5	27.0	22.0	26.0	31.0	21.2	21.0
Silicate (1.18-0.600 mm)	27.5	33.0	35.4	27.8	43.0	41.0	40.5	41.5	40.5	46.0	40.6	35.3
Silicate (0.600-0.300 mm)	50.5	44.0	56.3	57.7	58.0	57.5	58.0	63.0	59.5	57.5	57.7	58.1
Silicate (0.300-0.150 mm)	65.5	59.0	68.3	70.4	67.0	66.0	72.5	71.5	75.0	62.0	71.8	67.6
Silicate (0.150-0.075 mm)	77.0	70.5	76.6	81.9	75.0	74.5	77.5	70.5	67.0	68.5	79.5	76.7
Reported Silicate (weighted average) (%)	42.5	38.5	44.5	44.4	51.4	49.5	49.1	48.8	50.2	48.2	47.9	45.0
Carbonate (4.75-2.36 mm)	85.0	80.0	78.5	80.0	59.5	60.5	76.0	74.5	78.0	76.0	70.0	77.5
Carbonate (2.36-1.18 mm)	79.9	84.0	74.9	73.5	57.5	59.0	71.5	73.0	72.5	68.0	71.2	74.8
Carbonate (1.18-0.600 mm)	71.5	67.0	64.1	70.4	48.5	50.5	56.0	53.0	59.5	54.0	52.5	61.7
Carbonate (0.600-0.300 mm)	48.5	55.0	42.7	39.9	33.5	37.0	40.0	31.5	40.0	42.0	37.1	40.0
Carbonate (0.300-0.150 mm)	34.5	40.5	30.2	28.1	25.0	29.0	25.5	24.5	24.0	36.0	21.6	29.0
Carbonate (0.150-0.075 mm)	19.0	28.0	20.9	15.7	17.0	18.0	14.5	20.0	30.0	29.5	14.3	18.7
Reported Carbonate (weighted average) (%)	56.3	61.1	54.2	53.5	40.8	43.5	48.4	46.5	49.0	51.1	45.2	51.4
Conglomerate, sandstone, quartzite (4.75-2.36 mm)											4.0	2.0
Conglomerate, sandstone, quartzite (2.36-1.18 mm)											6.7	2.4
Conglomerate, sandstone, quartzite (1.18-0.600 mm)											6.4	2.0
Conglomerate, sandstone, quartzite (0.600-0.300 mm)											4.4	1.9
Conglomerate, sandstone, quartzite (0.300-0.150 mm)											4.3	1.4
Conglomerate, sandstone, quartzite (0.150-0.075 mm)											0.0	0.0
Reported Conglomerate, sandstone, quartzite (weighted average) (%)											4.8	1.8
Shale (4.75-2.36 mm)	1.0		0.5	0.5	2.0	2.0	1.0	0.5	1.0		0.5	
Shale (2.36-1.18 mm)	0.9		0.5	0.5	2.5	4.5	1.0	3.0	0.5		0.5	0.5
Shale (1.18-0.600 mm)	1.0			0.5	4.0	3.0	2.5	4.5			0.5	0.5
Shale (0.600-0.300 mm)			0.5		2.5	2.5	1.0	2.0				
Shale (0.300-0.150 mm)					1.5	1.0	0.5					
Shale (0.150-0.075 mm)		0.5		0.4	1.5	1.0	1.5					
Reported Shale (weighted average) (%)	0.4		0.3	0.2	2.5	2.4	1.2	2.1	0.2		0.2	0.2
Mica (4.75-2.36 mm)												
Mica (2.36-1.18 mm)	0.5											
Mica (1.18-0.600 mm)					1.0	1.5						
Mica (0.600-0.300 mm)				0.5	3.5	2.0		1.5	0.5	0.5	0.8	
Mica (0.300-0.150 mm)		0.5	0.5	0.5	4.5	3.5	0.5	1.5	1.0	2.0	2.6	1.9
Mica (0.150-0.075 mm)	3.0	1.0	2.0	1.2	6.0	6.5	2.0	3.0	3.0	2.0	6.3	4.6
Reported Mica (weighted average) (%)	0.2	0.1	0.1	0.3	2.4	1.8	0.2	0.8	0.5	0.6	1.0	0.5
Chert (4.75-2.36 mm)	0.5		0.5	0.5	3.0	6.0	1.5	1.0	0.5	0.5		0.5
Chert (2.36-1.18 mm)	0.5				4.5	5.0	0.5	2.0	1.0	1.0	0.5	1.4
Chert (1.18-0.600 mm)			0.5	0.9	3.5	4.0	1.0	1.0				0.5
Chert (0.600-0.300 mm)				0.5	2.5	1.0	1.0	1.5				
Chert (0.300-0.150 mm)			0.5	1.0	2.0	0.5	0.5	1.5				
Chert (0.150-0.075 mm)			0.5	0.8	0.5		1.5	4.0				
Reported Chert (weighted average) (%)	0.1		0.3	0.6	2.8	2.7	0.9	1.6	0.2		0.1	0.4

Laboratory Number	5	5	14	14	15	15	27	27	47	47	80	80
Sample Number	1.15	2.15	1.15	2.15	1.15	2.15	1.15	2.15	1.15	2.15	1.15	2.15
Cemented Particles (4.75-2.36 mm)	0.5				0.5	0.5	0.5	0.5			1.5	0.5
Cemented Particles (2.36-1.18 mm)					0.5							
Cemented Particles (1.18-0.600 mm)												
Cemented Particles (0.600-0.300 mm)												
Cemented Particles (0.300-0.150 mm)												
Cemented Particles (0.150-0.075 mm)												
Reported Cemented Particles (weighted average) (%)	0.1				0.1	0.1		0.1			0.2	0.1
Sulphide rocks and minerals (4.75-2.36 mm)												
Sulphide rocks and minerals (2.36-1.18 mm)												
Sulphide rocks and minerals (1.18-0.600 mm)												
Sulphide rocks and minerals (0.600-0.300 mm)												
Sulphide rocks and minerals (0.300-0.150 mm)												
Sulphide rocks and minerals (0.150-0.075 mm)								0.5				
Sulphide rocks and minerals (weighted average) (%)												
Oxide minerals (4.75-2.36 mm)												
Oxide minerals (2.36-1.18 mm)												
Oxide minerals (1.18-0.600 mm)												
Oxide minerals (0.600-0.300 mm)	1.0	1.0										
Oxide minerals (0.300-0.150 mm)							0.5					
Oxide minerals (0.150-0.075 mm)	1.0						3.0	2.0				
Reported Oxide minerals (weighted average) (%)	0.4	0.3					0.2	0.1				
Contamination (4.75-2.36 mm)				0.5								
Contamination (2.36-1.18 mm)												
Contamination (1.18-0.600 mm)												
Contamination (0.600-0.300 mm)												
Contamination (0.300-0.150 mm)												
Contamination (0.150-0.075 mm)												
Reported Contamination (weighted average) (%)				0.5								
Other #1 - soft, weak carbonate (4.75-2.36 mm)			1.0	0.5								
Other #1 - soft, weak carbonate (2.36-1.18 mm)				1.5								
Other #1 - soft, weak carbonate (1.18-0.600 mm)				0.4								
Other #1 - soft, weak carbonate (0.600-0.300 mm)			0.5	1.4								
Other #1 - soft, weak carbonate (0.300-0.150 mm)			0.5									
Other #1 - soft, weak carbonate (0.150-0.075 mm)												
Reported Other #1 - soft, weak carbonate (weighted average) (%)			0.4	0.8								
Other #2 -friable, weak granite (4.75-2.36 mm)			1.5									
Other #2 -friable, weak granite (2.36-1.18 mm)				0.5								
Other #2 -friable, weak granite (1.18-0.600 mm)												
Other #2 -friable, weak granite (0.600-0.300 mm)												
Other #2 -friable, weak granite (0.300-0.150 mm)												
Other #2 -friable, weak granite (0.150-0.075 mm)												
Reported Other #2 -friable, weak granite (weighted average) (%)			0.2	0.1								
Gradation (% retained)												
(4.75-2.36 mm)	12.1	14	14.3	14.1	15.6	15.7	13.9	15.6	13.6	13.5	15.9	15.3
(2.36-1.18 mm)	10.6	12.8	15	14	11.9	12.2	13.1	13.9	11.9	13.9	12.3	13.2
(1.18-0.600 mm)	16.6	18	19.7	19.4	18.4	18.3	18.3	18.7	18	19.5	17.5	18.2
(0.600-0.300 mm)	32.5	31	30.5	31	31	31.2	31.9	31.6	32.3	32.2	30.6	31
(0.300-0.150 mm)	20.5	17.8	16.7	17.5	18.2	17.9	19.2	17.3	20	17.7	19.8	18.8
(0.150-0.075 mm)	3.9	3.2	3	3.1	3.8	3.6	3.6	2.9	3.1	2.5	3.2	2.8
pass 75 µm	0.9	0.4	0.8	0.9	1.1	1.1	nr	nr	1.1	0.8	0.7	0.6
Total	97.1	97.2	100	100	100	100	100	100	100	100.1	100	99.9
total without pass 75	96.2	96.8	99.2	99.1	98.9	98.9	100	100	98.9	99.3	99.3	99.3

Laboratory Number	88	88	96	96	101	101	109	109	152	152	350	350
Sample Number	1.15	2.15	1.15	2.15	1.15	2.15	1.15	2.15	1.15	2.15	1.15	2.15
Silicate (4.75-2.36 mm)	30.0	28.5	19.5	22.5	15.6	17.3	16.0	15.5	42.5	30.0	21.0	23.0
Silicate (2.36-1.18 mm)	40.0	48.0	21.5	32.0	19.2	26.0	25.0	23.5	47.5	39.0	21.3	35.1
Silicate (1.18-0.600 mm)	47.2	59.3	35.0	37.0	50.2	36.4	45.5	38.0	57.0	55.0	32.7	46.6
Silicate (0.600-0.300 mm)	65.3	75.5	45.5	53.5	65.5	53.8	58.0	59.0	71.5	64.0	61.7	53.2
Silicate (0.300-0.150 mm)	77.0	76.0	66.0	70.5	76.2	64.8	73.0	74.0	83.5	71.5	67.3	67.2
Silicate (0.150-0.075 mm)	75.0	78.5	71.5	73.5	91.1	82.2	56.5	58.0	84.5	76.5	79.4	87.4
Reported Silicate (weighted average) (%)	56.4	63.3	41.6	46.6	51.9	45.7	49.1	47.7	65.2	56.2	46.6	50.0
Carbonate (4.75-2.36 mm)	66.0	68.5	78.0	74.5	83.9	82.1	82.0	84.0	54.5	65.0	78.1	77.0
Carbonate (2.36-1.18 mm)	58.0	48.0	76.5	66.0	80.2	73.1	72.0	72.0	46.5	57.0	77.8	64.9
Carbonate (1.18-0.600 mm)	49.2	37.2	63.0	60.5	49.4	62.8	52.5	60.0	37.0	40.0	65.4	52.5
Carbonate (0.600-0.300 mm)	32.7	23.5	48.5	44.0	34.5	45.9	37.5	38.0	25.0	33.0	36.8	45.3
Carbonate (0.300-0.150 mm)	20.0	21.0	26.0	26.5	23.5	33.4	26.5	24.0	13.0	24.5	30.7	31.3
Carbonate (0.150-0.075 mm)	15.0	8.5	16.0	12.5	7.7	17.0	21.0	21.0	6.5	17.5	19.6	12.1
Reported Carbonate (weighted average) (%)	40.4	33.4	53.4	50.1	47.8	53.5	46.8	48.5	30.3	39.7	51.9	49.1
Conglomerate, sandstone, quartzite (4.75-2.36 mm)												
Conglomerate, sandstone, quartzite (2.36-1.18 mm)												
Conglomerate, sandstone, quartzite (1.18-0.600 mm)												
Conglomerate, sandstone, quartzite (0.600-0.300 mm)												
Conglomerate, sandstone, quartzite (0.300-0.150 mm)												
Conglomerate, sandstone, quartzite (0.150-0.075 mm)												
Reported Conglomerate, sandstone, quartzite (weighted average) (%)												
Shale (4.75-2.36 mm)	1.5	2.5	1.5	1.5		0.3	0.5		0.5	3.5	0.4	
Shale (2.36-1.18 mm)	1.0	1.5	1.0	0.5		0.7	2.0	2.0	5.0	2.0		
Shale (1.18-0.600 mm)	1.5	1.5	1.5	2.0	0.4	0.8	2.0	1.5	4.5	4.5		
Shale (0.600-0.300 mm)			5.5				3.0	1.5	1.0	1.5		
Shale (0.300-0.150 mm)			1.0	0.5		0.9			0.5			
Shale (0.150-0.075 mm)			1.0						1.0			
Reported Shale (weighted average) (%)	0.6	0.8	2.5	0.8	0.1	0.4	1.6	1.0	1.9	2.0	0.1	
Mica (4.75-2.36 mm)	1.0											
Mica (2.36-1.18 mm)	1.0	2.0										
Mica (1.18-0.600 mm)	1.5	0.5							0.5			0.5
Mica (0.600-0.300 mm)	2.0	1.0	0.5	0.5		0.3	1.0	1.0	0.5	0.5		1.0
Mica (0.300-0.150 mm)	1.0	0.5	1.5	0.5	0.3	0.9		1.0		1.0		0.5
Mica (0.150-0.075 mm)	0.5	0.0	0.5	2.0	1.2	0.8	2.0	1.5		0.5	0.9	0.5
Reported Mica (weighted average) (%)	1.4	0.7	0.4	0.4	0.1	0.3	0.5	0.6	0.2	0.4		0.5
Chert (4.75-2.36 mm)	0.5		1.0	1.0			1.5	0.5	2.0	1.5		
Chert (2.36-1.18 mm)		0.5	1.0	1.5	0.3	0.2	1.0	2.0	1.0	2.0	0.5	
Chert (1.18-0.600 mm)		1.0	0.5	0.5					1.0	0.5	0.9	0.5
Chert (0.600-0.300 mm)				0.5				0.5		1.0	0.5	0.5
Chert (0.300-0.150 mm)			1.0									
Chert (0.150-0.075 mm)			1.0									
Reported Chert (weighted average) (%)	0.1	0.2	0.6	0.6			0.3	0.5	0.6	0.9	0.4	0.2

Laboratory Number	88	88	96	96	101	101	109	109	152	152	350	350
Sample Number	1.15	2.15	1.15	2.15	1.15	2.15	1.15	2.15	1.15	2.15	1.15	2.15
Cemented Particles (4.75-2.36 mm)	1.0	0.5		0.5	0.5	0.3			0.5			
Cemented Particles (2.36-1.18 mm)					0.3			0.5			0.5	
Cemented Particles (1.18-0.600 mm)	0.5	0.5									0.5	0.5
Cemented Particles (0.600-0.300 mm)												0.5
Cemented Particles (0.300-0.150 mm)												
Cemented Particles (0.150-0.075 mm)												
Reported Cemented Particles (weighted average) (%)	0.2	0.2			0.1			0.1	0.1		0.2	0.2
Sulphide rocks and minerals (4.75-2.36 mm)												
Sulphide rocks and minerals (2.36-1.18 mm)												
Sulphide rocks and minerals (1.18-0.600 mm)												
Sulphide rocks and minerals (0.600-0.300 mm)												
Sulphide rocks and minerals (0.300-0.150 mm)												
Sulphide rocks and minerals (0.150-0.075 mm)												
Sulphide rocks and minerals (weighted average) (%)												
Oxide minerals (4.75-2.36 mm)											0.4	
Oxide minerals (2.36-1.18 mm)												
Oxide minerals (1.18-0.600 mm)											0.5	
Oxide minerals (0.600-0.300 mm)				1.5					2.0		1.0	
Oxide minerals (0.300-0.150 mm)	2.0	2.5	4.5	2.0			0.5	1.0	3.0	3.0	2.0	1.0
Oxide minerals (0.150-0.075 mm)	9.5	13.0	10.0	12.0			20.5	19.5	8.0	5.5		
Reported Oxide minerals (weighted average) (%)	0.9	1.3	1.4	1.5			1.6	1.6	1.7	0.9	0.8	0.2
Contamination (4.75-2.36 mm)												
Contamination (2.36-1.18 mm)												
Contamination (1.18-0.600 mm)												
Contamination (0.600-0.300 mm)												
Contamination (0.300-0.150 mm)												
Contamination (0.150-0.075 mm)												
Reported Contamination (weighted average) (%)												
Other #1 - soft, weak carbonate (4.75-2.36 mm)												
Other #1 - soft, weak carbonate (2.36-1.18 mm)												
Other #1 - soft, weak carbonate (1.18-0.600 mm)												
Other #1 - soft, weak carbonate (0.600-0.300 mm)												
Other #1 - soft, weak carbonate (0.300-0.150 mm)												
Other #1 - soft, weak carbonate (0.150-0.075 mm)												
Reported Other #1 - soft, weak carbonate (weighted average) (%)												
Other #2 -friable, weak granite (4.75-2.36 mm)												
Other #2 -friable, weak granite (2.36-1.18 mm)												
Other #2 -friable, weak granite (1.18-0.600 mm)												
Other #2 -friable, weak granite (0.600-0.300 mm)												
Other #2 -friable, weak granite (0.300-0.150 mm)												
Other #2 -friable, weak granite (0.150-0.075 mm)												
Reported Other #2 -friable, weak granite (weighted average) (%)												
Gradation (% retained)												
(4.75-2.36 mm)	14.2	13.5	15.8	17.2	14.8	13.6	13.1	13.6	14.2	15	13.9	15.6
(2.36-1.18 mm)	13.1	11.7	12.3	13.2	13.5	11.5	12.2	12.2	12.1	12.7	13.1	13.9
(1.18-0.600 mm)	18.1	17.9	18.3	17.4	18.6	18.1	17.4	18	17.2	18.1	18.3	18.7
(0.600-0.300 mm)	30.5	31.4	30.2	28.8	31.7	33.6	30.6	30.5	30.3	30.2	31.9	31.6
(0.300-0.150 mm)	18.3	19	17.6	17.3	17.6	19.2	19.3	18.4	19.1	18.1	19.2	17.3
(0.150-0.075 mm)	2.5	2.9	2.6	2.7	3.1	3.3	3.1	2.8	3.1	2.7	3.6	2.9
pass 75 µm	3.3	3.6	3.2	3.4	0.7	0.7	4.3	4.5	3.9	3.2		
Total	100	100	100	100	100	100	100	100	99.9	100	100	100
total without pass 75	96.7	96.4	96.8	96.6	99.3	99.3	95.7	95.5	96	96.8	100	100

Appendix F1: Production Laboratory Ratings

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
2	9	30.0	10	10	8	**96**
4	7	28.4	10	10	8	**91**
8	10	29.7	10	8	10	**97**
9	10	20.5	0	8	0	**55**
12	8	25.4	6	4	10	**76**
13	10	28.6	10	10	10	**98**
15	8	27.3	10	10	10	**93**
16	3	13.9	0	10	0	**38**
17	10	23.2	10	7	3	**76**
18	10	28.1	9	9	10	**94**
19	10	26.7	1	10	10	**82**
20	10	30.0	10	10	10	**100**
21	10	25.4	0	9	10	**78**
22	10	29.5	10	10	10	**99**
23	0	25.6	10	8	8	**74**
25	10	27.8	10	10	10	**97**
26	10	22.9	8	10	9	**86**
27	10	29.7	8	10	10	**97**
28	9	28.4	10	10	8	**93**
29	8	25.6	10	10	10	**91**
30	10	28.1	9	10	10	**96**
31	7	26.2	9	10	7	**85**
32	10	25.6	10	7	10	**89**
33	10	29.5	10	10	9	**98**
34	7	20.5	0	7	0	**49**
35	10	29.7	10	10	10	**100**
36	10	21.0	7	6	5	**70**
37	8	28.6	9	10	8	**91**
38	10	26.7	7	8	9	**87**
39	8	27.3	10	6	10	**88**
42	10	23.7	10	7	8	**84**
43	10	30.0	8	10	8	**94**
44	10	30.0	10	8	9	**96**
45	9	28.1	5	6	9	**82**
46	10	23.2	0	6	3	**60**
47	4	27.5	10	9	10	**86**

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
52	0	27.3	0	10	10	68
54	10	23.7	10	10	8	88
56	6	18.8	3	7	7	60
58	10	23.5	5	7	10	79
59	10	29.2	10	9	10	97
60	7	23.7	0	7	0	54
61	10	29.7	10	10	10	100
62	8	29.5	10	9	8	92
63	10	24.5	9	10	10	91
64	10	25.1	8	4	8	79
65	10	25.6	9	4	8	81
67	10	23.2	10	9	7	85
68	10	28.9	10	9	10	97
69	10	28.1	1	10	5	77
70	10	28.4	10	10	10	98
71	10	19.4	3	3	10	65
72	10	23.7	6	7	8	78
73	10	23.2	0	5	0	55
74	9	28.9	8	10	10	94
75	10	25.4	10	9	10	92
76	9	29.5	9	10	10	96
77	0	22.4	0	1	0	33
79	10	28.9	10	10	10	98
80	7	28.1	9	10	10	92
81	10	27.5	8	10	8	91
83	9	19.1	10	7	10	79
85	6	24.8	9	9	9	83
86	5	27.0	10	7	7	80
89	9	27.3	10	10	8	92
90	10	29.7	10	9	10	98
93	10	13.4	10	9	10	75
95	10	29.5	10	10	10	99
97	7	28.9	10	8	10	91
98	4	27.3	9	10	0	72
99	9	27.8	10	8	9	91
100	10	27.5	10	10	3	86
101	10	28.4	9	9	10	95
102	10	29.5	8	10	10	96
103	10	30.0	10	10	10	100
107	9	28.1	6	10	0	76
108	8	29.2	5	10	0	75
110	2	27.5	10	6	10	79
112	10	27.8	6	8	10	88

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
113	10	23.5	7	0	5	65
114	9	28.9	0	10	0	68
115	10	18.8	0	10	0	55
116	10	27.8	10	10	10	97
117	5	27.0	0	8	0	57
118	10	24.8	10	10	10	93
119	0	17.7	0	2	0	28
120	8	27.0	9	10	0	77
121	10	30.0	10	10	0	86
122	9	23.2	10	10	10	89
124	10	25.9	9	10	9	91
126	10	20.2	10	10	10	86
127	10	20.2	9	8	10	82
128	10	28.4	10	9	10	96
129	10	26.2	10	10	10	95
137	10	26.5	7	5	10	84
138	10	27.3	10	10	10	96
139	10	22.6	9	10	10	88
140	10	28.6	9	10	0	82
141	10	28.4	10	9	9	95
144	10	26.5	0	9	0	65
145	9	21.8	10	9	10	85
146	7	26.2	10	10	10	90
147	10	27.5	9	8	4	84
149	9	26.5	10	10	9	92
150	7	30.0	9	10	10	94
151	9	23.5	0	9	0	59
154	10	29.2	10	10	10	99
156	9	6.3	0	9	0	35
157	10	27.5	9	10	10	95
158	9	19.6	9	10	10	82
159	10	23.2	10	6	8	82
160	8	26.5	7	10	9	86
161	10	28.1	10	9	4	87
163	8	28.4	10	7	9	89
164	10	28.4	10	10	9	96
167	9	29.5	0	8	10	81
168	10	27.5	10	9	10	95
169	5	27.3	10	10	10	89
171	1	24.8	8	6	3	61
172	6	27.3	0	10	10	76
175	10	29.2	8	9	8	92
176	0	23.7	9	0	9	60

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
177	6	27.3	10	8	10	88
178	10	24.5	0	9	4	68
179	10	26.5	9	10	9	92
180	10	27.0	0	9	8	77
181	8	27.5	1	10	9	79
182	7	28.9	0	10	10	80
183	10	25.4	10	10	8	91
184	10	20.7	10	9	10	85
186	10	27.5	0	10	0	68
187	10	28.1	10	10	8	94
188	10	29.2	10	10	10	99
191	10	21.5	10	10	5	81
193	10	28.6	10	10	10	98
194	5	27.5	0	9	0	59
195	8	25.6	10	0	10	77
196	5	28.9	0	7	0	58
198	10	27.3	10	8	9	92
199	10	29.7	10	10	10	100
200	10	28.1	10	10	9	96
205	7	24.3	4	9	8	75
210	10	26.2	10	3	0	70
214	10	28.4	8	10	9	93
216	10	30.0	10	8	10	97
217	10	28.4	9	9	10	95
219	10	26.7	10	10	10	95
232	5	20.7	7	3	4	57
234	10	28.6	0	9	9	81
235	4	20.7	10	10	9	77
236	7	25.9	10	10	10	90
245	10	27.3	10	9	10	95
248	8	28.4	10	9	10	93
249	8	26.7	5	8	10	82
250	7	23.5	10	9	10	85
251	8	28.4	9	9	9	91
253	10	25.6	0	10	0	65
254	10	26.7	0	10	1	68
255	4	30.0	10	6	9	84
257	10	26.5	0	3	0	56
258	8	30.0	9	10	10	96
260	8	25.4	8	9	10	86
261	0	26.2	9	10	10	79
262	8	28.1	10	10	10	94
263	5	24.8	9	10	8	81

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
264	10	27.5	10	9	8	92
266	5	21.8	5	6	0	54
268	6	15.0	7	6	9	61
269	8	26.7	10	8	7	85
271	10	28.4	10	9	0	82
272	10	28.9	0	10	10	84
274	10	24.5	7	9	10	86
275	8	28.9	10	10	10	96
276	10	25.4	9	10	10	92
277	8	25.6	10	10	0	77
278	8	28.4	0	8	0	63
279	10	22.9	9	0	10	74
280	10	28.1	10	10	10	97
282	10	29.5	9	10	5	91
285	10	25.6	4	9	8	81
287	8	3.5	0	10	0	31
288	10	23.2	10	2	10	79
290	7	22.4	10	7	7	76
291	10	26.2	10	9	8	90
293	9	29.7	0	10	7	80
294	10	30.0	10	9	10	99
296	6	28.6	9	9	9	88
297	10	19.6	10	8	10	82
300	10	27.5	10	10	9	95
301	9	28.9	0	10	0	68
302	7	26.5	10	9	6	84
303	10	28.9	10	10	8	96
305	6	19.1	0	10	0	50
307	10	27.3	0	9	0	66
308	8	21.8	10	8	10	83
309	10	29.2	0	10	10	85
310	9	28.4	10	8	8	91
311	6	26.2	9	10	10	87
312	10	26.2	9	10	10	93
313	9	26.7	0	10	9	78
314	10	25.1	8	5	9	82
315	10	29.7	9	5	10	91
316	10	27.3	10	10	10	96
318	9	27.3	8	10	7	88
320	10	27.3	0	9	0	66
321	10	25.9	4	10	10	86
322	9	24.3	8	9	10	86
323	10	27.5	9	9	10	94

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-607 % Crushed Particles	LS-621 % Asphalt Coated	LS-608 % Flat & Elongated	Rating
324	8	27.3	10	9	9	**90**
325	8	30.0	8	10	10	**94**
326	9	24.3	10	9	0	**75**
327	0	19.4	0	8	10	**53**
328	10	30.0	10	9	10	**99**
329	0	27.8	0	9	0	**53**
331	5	22.4	0	0	0	**39**
332	8	29.7	0	9	0	**67**
333	0	28.1	0	8	3	**56**
335	9	28.4	0	10	0	**68**
337	0	30.0	0	5	0	**50**
339	5	25.1	0	10	0	**57**
340	10	26.7	10	10	10	**95**
341	10	27.0	10	10	9	**94**
342	0	10.9	5	9	10	**50**
344	10	29.2	10	10	10	**99**
345	10	30.0	10	3	8	**87**
346	7	27.0	10	9	6	**84**

Appendix F2: Full Service Aggregate Laboratory Ratings

FULL SERVICE AGGREGATE LABORATORY RATINGS 2015

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 $MgSO_4$ (CA)	LS-607 % Crush	LS-621 % Asphalt	LS-608 % Flat & Elongated	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-623 One-Point Proctor	LS-619 MDA (FA)	Rating
8	10	29.7		10	10	10	8	10	10	10	9.5	10	9	97
13	10	28.6		10	10	10	10	10	10	10	10	7	10	97
15	8	27.3		9.5	10	10	10	10	10	7	8	10	8	91
18	10	28.1		7.5	10	9	9	10	6	5	10	9	10	88
19	10	26.7	10	10		1	10	10	10	9	10	10	10	91
22	10	29.5		10		10	10	10	10	10	10	9.7	10	99
23	0	25.6		9.5		10	8	8	8	9	6	9.3	10	80
27	10	29.7	10	9.5	10	8	10	10	10	10	10	10	10	98
28	9	28.4		10		10	10	8	10	9	8	9	9	93
31	7	26.2	8	9.5	10	9	10	7	5	8	3.5	1	10	76
35	10	29.7	7	10	10	10	10	10	10	10	9	9	10	96
37	8	28.6	10	10	10	9	10	8	8	10	10	5.3	10	91
38	10	26.7	6	9.5	9	7	8	9	9	10	10	6	8	85
39	8	27.3		7		10	6	10	5	8	8.5	10	9	84
47	4	27.5	10	10	10	10	9	10	10	10	8	10	8	91
56	6	18.8	9	10	6	3	7	7	8	10	10	9.3	8	75
59	10	29.2		5.5	10	10	9	10	10	10	9	10	9	94
61	10	29.7		4		10	10	10	7	10	8.5	9	10	91
69	10	28.1		6		1	10	5	2	7	7.5	9	10	74
75	10	25.4		8.5	8	10	9	10	10	9	10	10	10	93

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 $MgSO_4$ (CA)	LS-607 % Crush	LS-621 % Asphalt	LS-608 % Flat & Elongated	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-623 One-Point Proctor	LS-619 MDA (FA)	Rating
76	9	29.5		10	8	9	10	10	7	9	10		10	93
79	10	28.9		9		10	10	10	10	10	10	9	10	98
80	7	28.1	9	9	10	9	10	10	10	6	9	9.7	10	91
81	10	27.5		8		8	10	8	10	9	9.5	9	10	92
83	9	19.1		10	10	10	7	10	9	6	7	6.3	4	77
86	5	27		5		10	7	7	9	10	7.5	9.3	9	81
90	10	29.7		10	9	10	9	10	8		9.5		8	94
98	4	27.3		8.5	6	9	10	0	7	0	7.5	8	10	69
101	10	28.4		10	10	9	9	10	9	10	10	10	10	97
102	10	29.5		5.5		8	10	10	10	10	7	10	10	92
107	9	28.1		8	10	6	10	0	10	6	10		8	81
110	2	27.5		9	2	10	6	10	9	9	9	10	4	77
112	10	27.8		10	10	6	8	10	10	9	5	7	10	88
114	9	28.9		8.5	8	0	10	0	10	3	5	4	10	69
120	8	27		9.5		9	10	0	8	0	9	10	10	77
121	10	30		10	10	10	10	0	10	0	10	10	10	86
124	10	25.9		8		9	10	9	10	10	10	10	5	90
157	10	27.5		7.5	9	9	10	10	10	9	10		10	94
164	10	28.4		9.5	10	10	10	9	8	10	5		10	92
172	6	27.3		10	9	0	10	10	10	10	5	7.7	10	82
177	6	27.3		10		10	8	10	6	8	10		10	88
183	10	25.4		10	6	10	10	8	10	10	10	10	6	90
188	10	29.2	10	10	10	10	10	10	10	9	9.5	8.7	10	98
199	10	29.7		10		10	10	10	9	10	10	10	10	99
205	7	24.3		3.5		4	9	8	10	10	8.5	10	10	80
216	10	30		10	9	10	8	10	10	10	9.5	9.7	10	97
217	10	28.4		10	10	9	9	10	9		8.5		10	95
245	10	27.3		9		10	9	10	10	8	9	10	10	94

Lab No.	LS-601 Wash Pass	LS-602 Gradation	LS-603 LAA	LS-604 BRD/ABS (CA)	LS-606 $MgSO_4$ (CA)	LS-607 % Crush	LS-621 % Asphalt	LS-608 % Flat & Elongated	LS-618 MDA (CA)	LS-614 F/T	LS-605 BRD/ABS (FA)	LS-623 One-Point Proctor	LS-619 MDA (FA)	Rating
253	10	25.6		9.5		0	10	0	10	0	8	8	3	**65**
257	10	26.5		10	10	0	3	0	9	0	4	10	8	**65**
260	8	25.4		8.5	10	8	9	10	10	0	2	10	4	**75**
263	5	24.8		10	10	9	10	8	6	10	6.5	7.7	10	**84**
285	10	25.6		10	6	4	9	8	10	10	9.5	8.3	10	**86**
293	9	29.7		9.5	9	0	10	7	10	10	9.5	6.3	10	**86**
296	6	28.6		7.5		9	9	9	10	10	3	10	10	**86**
309	10	29.2		5.5	5	0	10	10	9	9	10	10	10	**84**
312	10	26.2		8.5	10	9	10	10	10	10	10	10	5	**92**
316	10	27.3		10	10	10	10	10	10	8	7	8.7	10	**94**
325	8	30		8.5		8	10	10	8	5	10	8	8	**87**
326	9	24.3		3.5		10	9	0	10	0	8	9.3	5	**68**

Appendix F3: Soil Laboratory Ratings

Lab No.	LS-702 Hydrometer Analysis	LS-703 & 4 Atterberg Limits	LS-705 Specific Gravity	Rating
8	8.0	9.7	10	92
9	9.0	9.3	10	94
12	7.2	5.0	9	71
13	9.0	9.0	10	93
15	10.0	9.0	10	97
18	9.8	9.3	10	97
19	10.0	9.0	10	97
20	9.8	9.7	10	98
21	8.6	9.3	8	86
22	10.0	10.0	10	100
23	9.4	9.0	6	81
27	9.4	9.7	9	94
28	7.8	8.3	10	87
29	8.4	9.7	10	94
30	9.8	10.0	8	93
31	9.8	10.0	10	99
32	8.2	9.3	0	58
35	9.6	10.0	10	99
37	9.4	9.3	10	96
38	8.8	7.7	2	62
44	10.0	10.0	10	100
46	8.0	7.7	10	86
47	9.6	9.7	9	94
52	9.8	4.3	0	47
54	9.0	5.7	0	49
56	5.4	10.0	10	85
58	9.6	9.3	8	90
59	9.8	10.0	10	99
62	10.0	9.0	8	90
63	7.6	10.0	9	89
64	8.2	10.0	9	91
68	9.0	10.0	10	97
69	6.8	9.0	9	83
71	9.2	10.0	10	97
72	6.0	10.0	10	87
74	9.8	8.7	10	95

Lab No.	LS-702 Hydrometer Analysis	LS-703 & 4 Atterberg Limits	LS-705 Specific Gravity	Rating
83	8.6	8.0	9	85
85	9.6	10.0	9	95
86	0.2	9.0	10	64
98	8.4	8.7	0	57
101	9.4	9.3	10	96
102	9.8	8.0	0	59
112	9.6	8.0	10	92
114	9.6	8.3	5	76
118	9.4	10.0	0	65
120	9.4	10.0	8	91
121	10.0	10.0	10	100
126	9.8	10.0	9	96
138	9.8	9.0	10	96
139	9.0	9.7	5	79
144	8.4	10.0	7	85
146	8.4	9.0	10	91
149	8.4	8.0	10	88
151	9.8	8.7	8	88
156	9.8	8.3	3	70
159	10.0	10.0	9	97
168	9.0	6.3	8	78
171	8.2	8.7	0	56
172	9.2	10.0	10	97
183	7.2	10.0	10	91
195	8.6	7.3	10	86
205	7.0	9.7	10	89
210	9.4	10.0	8	91
216	8.2	10.0	10	94
253	5.8	9.0	0	49
260	7.2	3.7	10	70
261	8.2	10.0	9	91
266	8.2	5.3	0	45
276	10.0	9.3	10	98
285	7.8	10.0	4	73
287	7.6	6.3	10	80
296	7.6	9.3	9	86

79	9.4	9.0	10	**95**
80	9.8	9.7	10	**98**
81	9.4	10.0	10	**98**
315	9.6	9.0	10	**95**
320	9.4	9.0	2	**68**
322	9.0	5.7	4	**62**

300	9.4	10.0	10	**98**
307	8.2	10.0	9	**91**
312	7.4	10.0	10	**91**
332	9.0	8.7	10	**92**
333	8.4	9.3	7	**82**
346	9.6	5.0	2	**55**

Appendix F4: Superpave Laboratory Ratings

Laboratory No.	T 304 Uncompacted Void Content	D2419/T 176 Sand Equivalent	ASTM D5821 % Fractured Particles	ASTM D4719 % Flat & Elongated	Rating
13	10	10	10	10	100
15	10	10	10	10	100
18	10	10	9	10	98
19	9	10	6	10	88
20	10	10	10	10	100
21	10	9	10	9	95
22	10	10	10	10	100
25	8	10	10	10	95
26	7	10	10	10	93
27	10	10	10	10	100
28	10	10	8	9	93
31	0	10	10	0	50
33	9	10	10	5	85
35	10	10	10	10	100
37	10	10	7	10	93
39	7	10	6	8	78
43	10	10	8	2	75
47	10	9	10	8	93
56	10	10	7	6	83
58	0	10	6	10	65
59	10	8	10	9	93
61	10	10	10	10	100
62	10	10	10	8	95
69	6	9	0	8	58
71	10	7	9	10	90
75	10	7	10	10	93
77	0	10	0	0	25
79	9	10	9	9	93
80	10	10	10	10	100
86	10	6	9	9	85
101	10	10	7	6	83
108	10	2	3	0	38
112	2	9	0	10	53

Laboratory No.	T 304 Uncompacted Void Content	D2419/T 176 Sand Equivalent	ASTM D5821 % Fractured Particles	ASTM D4719 % Flat & Elongated	Rating
114	0	8	5	0	33
115	9	--	8	0	60
120	9	10	9	0	70
121	10	10	10	0	75
124	10	8	9	9	90
157	8	7	10	7	80
172	8	10	0	10	70
183	0	8	10	10	70
188	9	10	10	10	98
193	10	10	10	10	100
199	8	7	10	9	85
216	10	10	10	8	95
217	2	7	9	10	70
245	8	10	10	6	85
253	8	3	8	0	48
255	8	9	10	10	93
257	7	6	6	0	48
263	8	10	10	7	88
271	0	10	10	0	50
285	9	8	10	6	83
293	9	7	9	8	83
296	10	7	7	10	85
300	3	9	0	10	55
312	9	8	8	8	83
316	10	9	9	10	95
325	10	10	8	10	95
326	7	10	10	0	68
340	10	7	10	8	88